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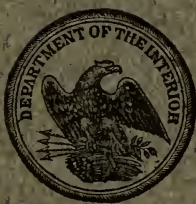
GOVERNMENT RECLAMATION WORK IN FOREIGN COUNTRIES

COMPILED FROM

CONSULAR REPORTS AND OFFICIAL DOCUMENTS

BY

EDWARD D. McQUEEN GRAY



WASHINGTON
GOVERNMENT PRINTING OFFICE
1909

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GOVERNMENT RECLAMATION WORK IN FOREIGN COUNTRIES.

By EDWARD D. McQUEEN GRAY.

INTRODUCTION.

On the 8th of March, 1907, a department circular, embodying a series of questions with respect to the nature and extent of the participation of foreign governments in the reclamation of land by means of irrigation, drainage, and unwatering, was addressed by the Department of State to consular officers abroad. The questions were as follows:

(1) What aid is extended by the Government to districts, municipalities, or private persons in the planning and execution of reclamation, drainage and irrigation works?

(2) Are works in any of these classes executed by the Government, or does the Government aid in their construction by making the necessary investigations and plans or by the contribution of funds, by extending its credit, or by subsidy?

(3) Does the Government, when it contributes to such work, recover its outlay? If so, what provisions are made for reimbursement?

(4) Is there any general law defining the aid which the Government may extend to provinces, to municipalities, to corporations, or to private parties for the execution of works which are to be of more than local benefit; and if so, to what class of work does the same apply? What are the provisions of the law? If convenient, furnish the full text of the law, translated when necessary. If the Government contributes to the cost of such works and the funds thus advanced are to be repaid, what is the rate of interest charged?

(5) To what extent do the districts or corporations or private interests participate in planning and in directing the execution of the works?

(6) What branch of the Government plans and constructs such works?

(7) For what length of time does the management of works in whose construction the Government has aided by financial contribution remain in the hands of the government officials?

(8) What conditions are always or usually imposed when the Government, by general or specific enactment, extends aid to enterprises of the character above named?

(9) How are costs apportioned to the Government, to provinces or States, to districts or municipalities, and to corporations or private individuals in case the Government participates in the execution of an enterprise by advancing the funds in whole or in part for the acquisition of the necessary properties and the construction of works?

(10) Give some specific examples, preferably of land reclamation work by protection against overflow, or by drainage, and of irrigation work.

(11) If a government concession makes land reclamation by irrigation or drainage possible, how and under what restrictions is the land made available for the farmer? In such cases are there any restrictions (1) as to the area of

public land which can be acquired by any one person, (2) amount of private land benefited held by any one person, (3) as to location of residence of owner on or near the land?

(12) What printed statistical or other material relating to these matters is available?

In reply to this circular 75 consular reports were received and referred to the Reclamation Service as originating the inquiry.

These reports are classified as follows:

I. Affirmative with respect to government participation in land reclamation in general. The substance of these reports is given on pages 6 to 102.

II. Affirmative with respect to government participation in land reclamation by drainage and unwatering only. The substance of these reports is given on pages 102 to 108.

III. Affirmative with respect to land reclamation by private enterprise, but negative in regard to government participation therein. The substance of these reports is given on pages 108 to 115.

IV. Negative in regard to land reclamation in general. It has not seemed necessary to print these reports.

It is to be regretted that returns have not been forthcoming from several countries in which land reclamation plays an important part in national economics, and also that some of the reports submitted were so meager as to be of little value. Others again, while more prolix, being couched in general terms, were not sufficiently precise or technical to be serviceable, either from an administrative or engineering standpoint. On the other hand, several of the reports showed that the writers had taken considerable pains to secure accurate information and these, especially when accompanied by official documents, were all that could be expected. Furthermore, in response to a direct request from the editor, copies of the annual reports of reclamation services were received from a number of foreign Governments; so that this digest, although necessarily concise, is fairly comprehensive.

In summarizing the matter contained in the following pages it may be remarked that no category of public works presents a greater variety of conditions than those which are comprised in the operations of a reclamation service, and that it is consequently impossible to lay down any rigid set of rules for general application; each case is tried and decided upon its merits, and procedure, even within the limits of a single province or canton, will usually be of the *pro re nata* order. The law provides the general principle, but a wide range is permitted in the particular application. Thus, in Prussia, the state subsidy varies between 20 and 60 per cent of the capital outlay; in Italy the syndicate interested may be assessed as little as 20 per cent, or as much as 70 per cent of the total cost; in Cape Colony the government may lend from 25 to 75 per cent of the value of the property at a low rate of interest; while even in India, where government irrigation work is expected to be a remunerative investment, vast reclamation enterprises, which offer no likelihood of being worked at a profit, are regularly undertaken with imperial sanction in the public interest.

Moreover, physical and climatic conditions, and the constituents of soil and water vary not merely between country and country, but between district and district to such an extent that the problems which call for solution in one part of the same country are frequently essentially distinct from those which present themselves in another.

The Lombard plain and Pontine district in Italy; the Zuider Zee and the Kempen in the Netherlands; the Tell and Sahara districts in Algeria are instances of this opposition of circumstances.

Comparison, therefore, between the methods followed in land reclamation in the United States and those pursued in other countries, unless contingently restricted, would in all likelihood prove misleading; and this is especially pertinent with respect to two of the most important items thereof; construction work and water rentals. The experience of the Indian engineers with respect to Smart's shutters and superstructures on weir crests is hardly applicable in a country whose rivers, with few exceptions, have a concentration of silt load less than one-sixth that of the Indus; nor could the masonry work on the Cavour Canal be reproduced here except at a cost to the landholder little short of ruinous. And with respect to rentals—perhaps the most important consideration in any reclamation project—the systems in vogue in those countries where water storage and supply have been a leading factor in economies for many centuries can hardly be regarded in this country for many years to come with other than an academic interest. To attempt to introduce here the system of compound classification of water rentals, which endeavors so to combine the two chief components—value of crop and distance from market—as to produce a coefficient that shall equalize as far as possible agricultural conditions throughout the whole of an irrigation district, would be to give the signal for wasteful and disastrous disputes and bickerings innumerable. Nor is the double fasl system of India, according to which two water rentals—one for the Kharif, the other for the Rabi crops—are obtained from the ryot, feasible or even desirable in this country, where it is usually to the interest of an irrigation system to close the canals during a considerable portion of the year.

It is, however, noteworthy that in the countries governmentally interested in reclamation, all such operations are conducted under a service head of a department of public works. Thus, everywhere abroad we find such naturally correlated problems of national interest as irrigation, drainage, control of water courses, inland navigation, harbor improvements, and the like, assigned to an appropriate division of public works. Sometimes, as in the Netherlands, the reclamation question is so important as to demand the services of a state department to itself; sometimes, as in Italy, irrigation and drainage problems are handled by the public works department in consultation with the ministry of agriculture and industry, both being financially subordinated to the ministry of the treasury; but in every foreign country all matters involving national action of this character are referred to some one branch of the administration specially equipped to deal with them. In this way all questions of water control and supply, which are naturally interdependent, not antagonistic, are studied in relation to one another, and the energy which would otherwise be lost in opposition and rivalry, is conserved and advantageously applied.

Another arrangement which seems worthy of consideration is the provision made in many countries for the evaluation, by means of a competent staff of government engineers, of those enterprises which the Government for various reasons is either not invited or unwilling

to undertake. For a moderate fee, varying according to the extent of the proposed enterprise, the Government will render a report not merely upon the engineering feasibility of the project, but also upon its financial prospects. The report will include a complete survey of the territory in question, plans and specifications, with estimates of probable cost of the constructions recommended by the government engineers; and also, in view of an application being made for financial assistance, a statement of the amount of the burden which may properly be laid upon the land benefited and the proportion thereof which may be safely advanced thereon. Armed with this report, the landowners or syndicate interested can go before the provincial or central government or apply for private capital to enable them to carry out the scheme. The Government will also, if required to do so (but in any case, if a government loan is procured), exercise control over the construction work and even over the maintenance of the system when in operation. When it is desired to carry out such a project with private capital, the government report gives a stability to the scheme which would otherwise be lacking and provides by the clause limiting the amount of the investment a valuable safeguard against overcapitalization and the watering of stock. It need hardly be stated that in these cases neither the original capital nor any subsequent additions thereto may be applied for except with the consent of the minister of the department concerned.

Another head of service in foreign public works which merits attention is the one known in Cape Colony, the Transvaal, and the Australian States as the "Boring Branch." Operating under different laws in different colonies, the principle is practically the same and consists in boring wells, largely at government expense, in remote parts of the country, for farmers and others who are unable to provide the necessary equipment. The government outfit is moved from one up-country station to another at the expense of the landowners, who also provide fuel, feed, and water, and defray about one-third of the actual cost of boring, the remainder being chargeable to the irrigation branch. In this manner many distant stations are furnished with permanent stock water and the productiveness of the whole area is greatly increased. In the artesian districts in New South Wales the water supply is under government control, no one being allowed to sink a well without a license, so that the interests of those already dependent upon the existing supply may be protected and the water of the whole area controlled and operated in the public interest. Some of the artesian systems thus controlled command more than 1,000,000 acres, the supply being conveyed in pipes and channels to every part of the district.

The above instances of a procedure varying from our own, which yet merits serious study and consideration, might easily be extended; but sufficient have been adduced to show that a perusal of the following pages may not merely prove of interest to the reclamation engineer, but furnish food for thought to those who are actively concerned in promoting the national welfare.

GENERAL GOVERNMENTAL PARTICIPATION IN LAND RECLAMATION.

AUSTRIA.

Government intervention and assistance in the reclamation of land, either by the regulation of water courses, drainage, or irrigation, are furnished both by the government of the province in which the area to be reclaimed is situated, acting through the provincial legislature, and by the Imperial Government, acting through the ministry of agriculture.

All ordinary contributions from the Imperial Government are furnished from a reclamation fund, placed at the disposal of the minister of agriculture, and arising from an annually voted appropriation of 1,000,000 crowns (about \$200,000), according to the provisions of the water law of 1884. The minister of agriculture is required to submit an account of the administration of this fund every year to the imperial parliament. The intention is to so administer the fund that all provinces applying for relief may, as far as possible, benefit equally.

The ordinary contributions from the reclamation fund are made upon application from the province interested, a special provincial law, approving the project and defining the character of the aid to be extended by the provincial government and applied for to the Imperial Government, having previously been passed by the provincial legislature.

For extraordinary contributions, such as those providing for relief to flooded districts, the regulation of a dangerous water course of unusual extent, the protection of riparian territory against annual submersion, or reclamation work of more than ordinary magnitude and importance, special legislation is necessary, the usual course being for a bill asking for the requisite appropriation to be presented to the imperial parliament, either by the minister of agriculture, or with his approval and support.

The financial aid extended by the imperial and provincial governments to reclamation projects is regulated as follows:

When government aid is desired in the reclamation of land, the parties directly interested—that is, the district, commune, or water association concerned in the enterprise—submit a petition to the provincial legislature asking for assistance, or present a bill to the same effect. The project, if favorably considered, is referred to a committee, who decide whether the work in question is to be undertaken, as—

(1) A provincial enterprise, part of the cost whereof is to be borne by the parties directly interested; or (2) a district, communal, or water association enterprise, part of the cost whereof is to be borne by the provincial government.

In the case of (1) the parties directly interested may be assessed up to, but not exceeding, 30 per cent of the estimated cost of the enterprise. The amount contributable from the reclamation fund may not exceed 30 per cent of the estimated cost (except as regards

the regulation of water courses, when the imperial contribution may be raised to 50 per cent of the estimated cost of the enterprise).

The work is then carried out as a provincial undertaking, and the balance of the cost is provided for in the provincial budget.

In the case of (2) the contribution obtainable from the provincial government is classified under two heads: (A) Protection of property against devastation by water, i. e., floods, breaking of river banks or levees, deposit in river channels, etc.; or (B) amelioration of property, either by drainage or irrigation.

In case of (A) the provincial contribution may not be less than 30 per cent of the estimated cost of the enterprise. The amount contributable from the reclamation fund may be equal to that granted by the provincial government.

In case of (B) the aid extended by the provincial government may take the form of either (*a*) a contribution of not less than 20 per cent of the estimated cost of the enterprise; or (*b*) a loan, bearing interest at the rate of not more than 4 per cent per annum, repayable in fixed installments of not less than 30 per cent of the estimated cost. In this case the contribution from the reclamation fund may also take the form of either a grant or a loan, no higher amount being contributable than that contributed by the provincial government.

Generally speaking, the operation of the various enactments for the promotion and subvention of reclamation enterprises is to divide the cost of these enterprises equally between the Imperial Government, the provincial government, and the parties directly interested. When these parties are represented by a district or commune, the government grants are usually nonrepayable; but when the work is undertaken by a water association, the government contributions generally take the form of a loan, amounting to about one-half of the estimated cost, bearing interest at 4 per cent per annum and repayable in equal annual installments.

In case a water association finds itself, owing to the act of God, in a state of temporary insolvency, the minister of agriculture may advance from the reclamation fund a sum sufficient to enable the association to meet its obligations. This loan bears interest at not more than 4 per cent, and is repayable in not more than five equal annual installments.

Besides the above financial assistance, the subsidized enterprises enjoy exemption from taxation by stamp duties connected with the transactions they have with the Government, by income tax on the interest on their debentures, etc.

All construction plans, whether for drainage, irrigation, or any other reclamation work of a public character, must be prepared by the engineers of the board of works in the province interested, and these plans are supplied free of charge to the district, commune, or association.

All construction work is done by public contract, the bids being submitted to the engineers of the board of works for their decision. The works are constructed under the supervision of the provincial engineers.

After construction, the maintenance of the works devolves upon a water association formed for the purpose. All expenditure in excess of the estimated cost must be borne by the water associations.

The following is a transcript of the portion of the law of June, 1884, relating to land reclamation:

I. Subject to the provisions of this law, the Government may grant financial assistance from the amelioration fund for the subvention of enterprises having for their object the protection of landed property against floods, or the enhancement of the value of such property by means of drainage or irrigation. But when an enterprise of public utility and advantage requires, owing to its importance or costliness, a subvention so great that the annual sum placed at the disposal of the ministry of agriculture would be depleted to the prejudice of other deserving enterprises, the decision as to the amount and source of the Government subvention lies with the imperial parliament.

II. For the creation of the aforesaid amelioration fund the sum of 1,000,000 crowns (about \$200,000) is included in the annual budget of the minister of agriculture. All repayments of capital and interest on advances are returned to the fund, and the surplus in hand at the close of each fiscal year is to be invested in interest-bearing securities. The amelioration fund is administered by the minister of agriculture, in conjunction with the minister of finance. These ministers dispose of the amounts to be contributed in accordance with the requirements of the budget as approved by the parliament. A report of the condition and management of the fund is to be submitted annually to parliament.

III. The contributions from the amelioration fund are to be so distributed among the provinces as to equalize as far as possible this branch of economic development in the different provinces of the Empire.

IV. The enterprise calling for subvention must be defined by a provincial law specially passed in its favor as either—

(a) An enterprise to be carried out by provincial funds, the proportion leviable from the interested parties—whether districts, communes, or water associations—being limited to not more than 30 per cent of the total estimated cost of the undertaking; or

(b) An enterprise to be carried out by certain districts, communes, or water associations, and subsidized from provincial funds, in which case the subsidy is limited as follows:

(1) For the protection of property against damage by water (breaking levees, silting up of channels, floods, etc.), a nonrepayable contribution of at least 30 per cent of the total estimated cost; or

(2) For reclamation or amelioration of property by irrigation or drainage, a nonrepayable contribution of at least 20 per cent of the total cost, or a loan carrying interest of not more than 4 per cent per annum, or not less than 30 per cent of the total estimated cost, repayable in fixed installments.

V. Furthermore, the following conditions are attached to the subvention

(1) The mode of carrying out the enterprise and the estimate of outlay must be based upon an agreement made with the Government;

(2) The Government must be granted a proper supervision of the undertaking;

(3) The permanent maintenance of the works to be constructed must be guaranteed by provisions in the provincial law governing the building or construction thereof, and

(4) In the cases mentioned in (b) of IV, the contribution from the provincial government must be assured to the enterprise by the meeting of all the obligations which devolve upon the provincial government as the owner of real estate.

VI. The subsidies which can be granted to such amelioration enterprises by the Government from the amelioration fund consists of the following:

(1) In the cases mentioned under (a) of IV, the maximum nonrepayable contribution is 30 per cent of the estimated cost; but if the enterprise has for its sole or partial object the diversion or regulation of dangerous streams, the contribution to this enterprise, or to the part thereof relating to the diversion or regulation, may be increased to 50 per cent of the estimated cost.

(2) In the cases mentioned under (b) of IV, a nonrepayable contribution or a loan carrying 4 per cent per annum interest at most, repayable in fixed installments, such sum not to exceed that granted by the provincial government.

VII. Besides the subsidy designated in VI upon the conditions named therein, an extraordinary loan may be made to a province in special circumstances (terms of repayment being fixed according to the circumstances), up to one-half of the sum which the province has to expend in the instance mentioned in IV,

section (a), or which, in the instances enumerated in IV, section (b), it has contributed to the enterprise either as a nonrepayable subsidy or as a loan.

VIII. The obligation of the State as an owner of real estate to make a contribution according to law is not affected because of a subsidy granted on the basis of VI.

IX. The Government may renounce its claim to land reclaimed by regulative work, or to such part of such land as would accrue to the amelioration fund in accordance with the law of water rights (whereby a share of the proceeds falls to those who bear the cost of the enterprise), in favor of a fund toward the maintenance of the work.

X. If by the act of God the solvency of a water association is temporarily impaired, the Government may advance from the amelioration fund a sum sufficient to enable the association to meet the interest on its bonded indebtedness, such loan to carry not more than 4 per cent interest per annum, and to be repayable in not more than five equal annual installments.

XI. The subsidizing of smaller reclamation enterprises from the funds at the disposal of the minister of agriculture in the Government budget is not interfered with by the foregoing provisions of this law.

BELGIUM.

Active participation by the Belgian Government in land reclamation through irrigation has been confined to the district known as the "Campines," situated in the northeast of Belgium, in the provinces of Antwerp and Limburg, and covering a tract of nearly 1,000,000 acres, originally a sandy waste, interspersed with dunes and marshes, and covered with a sparse growth of heath. During a period of acute industrial depression about sixty years ago, the Government of the day decided to adopt the recommendations of Chief Engineer Kummer, of the department of bridges and highways, and provide work for large numbers of unemployed workmen by attempting the canalization and reclamation of a portion of the Campine.

Having obtained authority by a law passed for the purpose in March, 1847, to expropriate the vacant lands in the possession of the communes, the Government proceeded to carry Kummer's plans into effect in the district lying between the Meuse and Scheldt, connecting these rivers by a system of main and subsidiary navigable canals. Kummer's system consisted in supplying a series of irrigating ditches by means of underground sluices from the water level above the locks of the canals, the residuary water being returned by catch ditches (reservoirs) to the canals below the locks. Systems of irrigation by borders and by submersion (for meadow lands) were practised.

During the years 1848 to 1880 the Government improved and equipped altogether 1,328 hectares (3,280 acres), selling the improved land to private parties. The estimated cost of preparing the plots of land, including the original purchase price, was about \$100 per acre, the land thus reclaimed realizing from \$120 to \$150 per acre. Since 1880, the Government has ceased active participation in such reclamation work, but has continued to grant permission to private individuals and communities to engage in it, and encourages the formation of water syndicates (wateringues). By this means about 1,800 more acres have been reclaimed within the Campine district, the Government furnishing free of charge all requisite plans and estimates.

All the irrigation sluices and syphons along the canals are controlled and operated by the Government, the expenses of operation and maintenance being divided among the water users in proportion

to the area supplied. This rule applies to private owners and syndicates alike. There is no governmental restriction as to the amount of land each water user may hold or operate, the local communal laws covering this matter and also the question of residence.

During the last ten years the Belgian Government has persistently directed the attention of private proprietors and communes to the benefits accruing from irrigation; but the area at present under irrigation does not in all probability exceed 6,000 acres.

Land reclamation by means of drainage may be said to be confined to projects for improving the sanitary condition of the marshy lands in the valleys of the navigable streams east of the Sambre and Meuse, in the provinces of Hainaut, Liege, Namur, and Luxemburg, particularly in the two last named. Throughout these districts are found marshes of limited area, rarely more than 250 acres in extent, whose unsanitary condition has seriously affected the inhabitants of the surrounding country. Systematized efforts to reclaim these swamps have been in progress for more than fifty years.

The reclamation of nearly all the larger marshes (75 acres and upward) that have been drained, has been effected through associations (wateringues), either individual or communal. The wateringues located in the valleys of navigable streams are under the direction of the ministry of public works; those in the valleys of unnavigable streams under that of the ministry of agriculture.

Subsidies are granted by the Government for the draining of marshy lands and swamps, when their condition is injurious to general health, or as a means of suppressing fogs, and as an aid to agriculture. These subsidies are nonrepayable.

There is no general law defining the aid which the Government may grant to provinces, municipalities, corporations, or private parties for land reclamation; when it has been decided to execute reclamation work at government expense, the State takes entire charge until the drainage construction work is completed, and thereafter the control, supervision, and maintenance of the works are vested in the wateringues if the lands belong to private owners united in a water association, or in a communal administration board if they belong to the communes. The state contribution is usually one-half of the total estimated cost.

The largest marshes which have been reclaimed up to the present time do not measure more than 250 acres in extent, and are principally found in the province of Luxemburg. The value of such land has been doubled and frequently trebled by drainage. The following is quoted from the Law of Irrigation of 1855:

15. Every landholder desiring to make use of a natural or artificial water supply which he has the right to dispose of, for the irrigation of his property, is entitled to bring these waters across intervening land, subject to previous payment of a just indemnity.

16. The owners of the lands below are obliged to receive the water from the lands thus irrigated, subject to the indemnity due them.

17. The same right of transit over intervening land is accorded on the same conditions to the owner of a marsh or piece of land wholly or partly submerged, in order to procure an outlet for injurious water, as also to the owner of wet land which has to be dried by means of open or closed drains.

18. All buildings, as well as the yards, gardens, parks, and inclosures appurtenant to dwellings, are excepted from the servitudes named in the three preceding sections,

19. Any landholder desiring to use water of which he has the right to dispose for the irrigation of his property may obtain, subject to the previous payment of a just indemnity, the right to abut the works necessary for his appropriation of water upon the property of the riparian proprietor opposite.

20. The riparian landholder upon whose property the works abut may obtain the right to the common use of the dam or weir by contributing to the expense of the construction and maintenance in proportion to the area of land irrigated and the quantity of water used.

Should the claim to common use not be set up until after the commencement or completion of the works, the riparian abuttee must bear the entire expense of any alterations necessary to adapt the construction to the irrigation of his property.

21. All disputes occasioned by the creation of the servitudes mentioned in the preceding sections, the question of the direction of the water conduit, its construction and dimensions, the construction work necessary for the intake of water, the maintenance of works already constructed and the payments due to the owner of the servient or dominant tenement, or to the riparian abuttee, shall be brought before the justice of peace of the canton in which the servient property is situated. The judge will give due consideration both to the rights of property and the economic value of the undertaking. His decision with regard to indemnity shall be final up to 100 francs; above that amount appeal may be taken to a superior tribunal.

22. The Government is authorized, wherever it deems it necessary, to publish, upon the advice of the permanent deputation of the provincial council, administrative regulations for the formation and organization of wateringues, having for their object the drainage, irrigation, or reclamation of land.

Digest of the royal decree of 1890 relative to the administration of the Irrigation Law of 1855 is as follows:

I. Landholders desirous of making use, for the irrigation of their property, of the waters of the canals and navigable and floatable channels of the Campine, must procure the permission of the minister of agriculture, industry, and public works, adding to their request a statement of the area to be irrigated and a plan of the proposed work.

II. The said minister will, in conformity with the provisions of the law of 1855, have control of all operations connected with the intake, use, and discharge of these waters.

III. Every intake of water from the canals of the Campine must be furnished with:

(1) Two gauges, divided in centimeters, placed and kept up at the expense of the water users, one at the upper and the other at the lower end of each intake.

(2) A sluice gate locked by a key. The gauges and sluice gates are constructed according to the designs and models furnished by the department, and installed according to its directions. The keys of the sluice gates are in charge of the officials appointed for this purpose.

IV. The scale plans, drawings, and any other technical information which, according to Article II, should accompany the official permission, are supplied without charge to the licensees. The traveling expenses of the officials, however, who are required to be on the spot to furnish explanations or instruction, and the wages of any workmen required for the same purpose, are payable by the licensees.

V. The works are executed according to the rules of good construction and in accordance with the directions furnished on the spot by the government officials.

When the works are completed, the licensees must affirm the condition thereof by means of a sworn statement drawn up in triplicate, and accompanied by plans, by the engineer in charge of the works. These documents must be certified by the licensees and approved on behalf of the minister of agriculture, industry, and public works. One copy is sent to the department; the two others are intended for the licensees and the engineer.

VI. Notice of any infraction of the conditions of the permit or of Article IV shall be given to licensees in the name of the minister. The licensees, if called upon either to complete the works already partly constructed or to demolish and reconstruct those portions of the work which have not been executed in the prescribed manner, must submit their statement of defense or

justification within one week after the service of the notice. If they fail to do so, or if their plea is not allowed by the department, they are granted two weeks in which to conform to the regulations; after which the department will act in accordance with the provisions of the law of 1855.

VII. The licensees may not alter the authorized works in any way without a special permit to that effect from the department. A service of water once established and prescribed may not be stopped without similar authorization.

VIII. If the conditions contained in the official authorization are found to be insufficient the licensees must conform to any additional conditions that may be imposed.

IX. When the department has been requested to regulate matters with respect to a tract of heath land subdivided among several proprietors and irrigated by one or more water intakes in common ownership, it calls the proprietors together with a view of arranging their respective interests to the general advantage and appoints a president and secretary of the association. A written report of each meeting must be made.

X. Licensees are required to maintain authorized and prescribed works in good condition, to the satisfaction of the government officials.

XI. The annual detail list of maintenance work required of the various water users with respect to the unkeep and cleansing of the laterals and drain ditches, is sent to the governor of the province within the first fortnight of the month of March, in each year, for inspection by the persons interested during the three weeks following. The work in question has to be carried out during the nonirrigation period.

XIII. Irrigation water is supplied whenever the proprietors apply for it, except in case of force majeure and stoppage, as provided by the law of 1855, or when a scarcity of water or the condition of the canals prevents irrigation, the Government being the judge of the circumstances.

XIV. Licensees or their representatives must give four days' notice of application for irrigating water to the official in charge. They may not allow the water furnished them to flow over their land without employing it according to the manner prescribed in their license, except by special permission.

XV. At the end of the irrigating season the sluice gates are hermetically closed and the intakes opening from the canals are completely separated from them either by check planks, sluice gates placed in the channels, or by cofferdams.

FRANCE.

The operations of the French Republic, in respect of reclamation work, are under the control of the direction de l'Hydraulique et des Améliorations Agricoles, a bureau of the ministry of agriculture.

According to the law of August, 1854, plans and preliminary studies for the construction of drainage works are provided by the bureau free of charge. Similar assistance is also provided toward the construction of irrigation and other reclamation works approved by the Government, at the request of the communes or the associations syndicales.

Irrigation works adjudged to be of sufficient public utility receive subsidies from the Government, and in some instances the Government has guaranteed to the investors in the enterprise an interest of 4 per cent per annum for a considerable term of years. According to a law passed in 1856 a sum of \$20,000,000 was placed in the charge of the ministry of agriculture for the purpose of encouraging and supporting the construction of drainage and reclamation works, and, by an arrangement between the Government and the Crédit Foncier, that establishment advances the money required by the companies. The principal, if not repaid previously, is due in twenty-five years, and until its repayment the bank holds a mortgage upon all the property of the company.

No general law exists defining the aid which the Government may extend to parties constructing irrigation works. The subsidies granted by the Government toward the expense of provision against overflow of rivers and drainage of marshes, sanitation of malarial districts, etc., are not repayable. The same applies to government contributions toward the expense of communal or syndicate reclamation work in general. A certain sum is voted annually by the parliament, in the budget of the minister of agriculture, to cover the expenses of the bureau de l'hydraulique agricole in making plans or studies for reclamation work, for the payment of the guaranteed interest on works already constructed, and for the construction of additional works previously approved by the bureau. When an irrigation canal exceeds 20 kilometers (12.42 miles) in length, a special act is required for the subsidy recommended.

When the Government constructs irrigation works at its own expense it endeavors to sell them outright as soon as a reasonable price can be obtained for them. This, as will be seen later, is of rare occurrence, the Government being generally a heavy loser by the transaction; consequently at the present day the Government is unwilling to construct any irrigation works at its own risk, preferring to accord substantial aid to the promoters of the enterprise.

The extent of this aid varies according to the circumstances of the case under consideration, averaging in most instances, in respect of irrigation work, one-third of the total cost of construction. In the case of drainage or protective work the government contribution is usually more liberal. In both cases the Government has at times contributed as much as one-half or even two-thirds of the expense. As previously stated, a government guarantee of interest at the rate of 4 per cent can be made to investors. This government aid is contingent upon the rest of the expense being divided between the department concerned and the commune or association syndicale.

When the commune or association syndicate desiring to construct reclamation work has received the approval and support of the bureau de l'hydraulique agricole and the plans have been passed upon by the minister of agriculture (who may modify them if he sees fit to do so), the work is carried out by the commune or syndicate, subject to the supervision and control of the officials of the bureau de l'hydraulique agricole, whose certificate is necessary in order to claim the subsidy from the Government. The act of 1856 requires the construction to be begun within two years of the granting of the franchise and to be completed within a specified period.

Among the most important reclamation enterprises of the last thirty years are the draining of the "Marais de Fos," 2,000,000 acres of the Landes of Gascony, and a quarter million acres of the Sologne district in Loir and Loir et Cher. In consequence of these operations the land has greatly increased in value—from \$15 per acre to over \$50—and more than four years have been added to the average length of life of the inhabitants. In the Landes, pine forests have been set out in the reclaimed districts, adding notably to the wealth of the country.

Since 1870 eight irrigation canals, with a flow of over 35 cusecs, have been completed, and twelve others are being constructed or increased.

Generally speaking, these government enterprises have been financially unsuccessful. The following instances will serve:

Canal de la Bourne (length 49 miles, irrigating 20,000 acres), cost \$2,316,000, was operated at a loss to the Government of \$44,390 in 1906, and in other years the deficit has been greater.

Canal de St. Martéry, cost \$1,930,000, was sold at auction for \$3,860.

Crau reclamation works, cost \$2,316,000 (interest guaranteed by Government), were operated in 1906 at a loss of \$96,000.

The reasons for this unsatisfactory state of affairs are excessive expense of construction (masonry aqueducts and tunnels for conveying water through mountainous regions); difficulty in collecting water rentals, many peasant proprietors refusing to fulfill their obligations; and redress, owing to the number of persons interested in evading the law, being hardly obtainable in the local courts; and in some instances, such as the Canal de la Durance, the water supplied, owing to the undesirable character of the solids in suspension, proved of no advantage as an aid to fertilization.

While the larger irrigation enterprises, therefore, have generally been financially unsuccessful, and it is impossible at present to induce investors to undertake them on their own account, many smaller enterprises, over a thousand in number, are being successfully operated by associations of water users, who, being all directly interested and benefited, see to it that all the members of the association meet their obligations.

In 1903 the direction de l'hydraulique was reorganized under the name of the direction de l'hydraulique et des améliorations agricoles, and the scope of its operations considerably enlarged. The activities of this bureau, besides the technical work properly connected with irrigation projects and such like reclamation enterprises, include research and experimental work of various kinds appertaining to the improvement of the soil, the proper culture thereof, and the different causes affecting the fertility of plants and districts. The direction consists of two separate bodies of officials—the service hydraulique, or engineer corps of the service, seconded, generally speaking, from the department of bridges and highways, which has charge of the construction and maintenance work; and the service des améliorations agricoles, comprising the inspectors who oversee the works under construction, the engineers who design the plans for the contemplated projects, and, in addition, a body of professors of agriculture whose services are placed at the disposal of the bureau. The chief reason for this reconstruction was that, owing to the ignorance of the farmers and water users, much land was improperly handled, much water wasted, and crops which, had a proper system of rotation been employed, would have been very remunerative, returned little or nothing to the cultivator. The officials of the amelioration service, accordingly, furnish advice to landowners and water users with regard to the irrigation of their land, the choice and rotation of crops, drainage, and so forth, and furnish skilled assistance in connection with various agricultural industries, such as creameries, distilleries, etc.

In order to aid the administration in forming a decision upon matter studied by the other services, a commission de l'hydraulique

et des améliorations agricoles has been created for the purpose of reporting to the minister of agriculture upon the various projects and proposals in connection with reclamation or land improvement. The commission acts practically as an advisory board to the ministry of agriculture.

In addition, a decree of 1905 created in connection with the direction de l'hydraulique a committee for the study of the various scientific questions affecting the hydraulic and amelioration services. The object of this committee is to instigate, coordinate, and centralize research work with reference to the many scientific questions which are connected with the operations of the two services, and in particular the following:

(1) The physical and mechanical properties of soils; their relations to their geological origin.

(2) Irrigation; composition, action, and use of irrigation water.

(3) Agricultural employment of sewage water and the residuary waters of factories.

(4) Inquiry into, selection, and culture of the best botanical species to introduce and propagate on irrigated soil, poor and waste land, peaty and swampy land, "alkali" or other salty soils, in order to render them valuable.

(5) Agricultural meteorology and physics.

(6) Application of machinery and motors in agricultural development work; utilization of electrical energy in agriculture and in rural industries.

The personnel of this committee, which is appointed by the minister of agriculture, consists of the director of the hydraulic and amelioration service and the chief engineers and inspectors of the two services, professors of the national agricultural college of chemistry in the national agronomic institute, of "Arts et Métiers" in the national conservatoire of agriculture in the agronomic station, directors of the experimental hydraulic agricultural station, of the Pasteur institute at Lille, of the seed-testing station, of the machine-testing station, the vice-president of the central meteorological bureau, and other officials of high standing. They are appointed for three years, and may be reappointed. The minister of agriculture is, *ex officio*, the president of the committee, and there are three vice-presidents, named by him, who are: The professor in charge of the chemical laboratories of the national agronomic institute; the inspector-general of mines, director of the geological map of France; the professor of "arts et métiers" at the conservatoire.

The activities of this committee, which will certainly prove of the utmost value with respect to the operations of the two services, appear to have been chiefly directed toward such subjects as the different characteristics and needs of soils with regard to their economic improvement, and the conditions of regions in which the geological formation has interfered with the water supply; the various means of protecting crops from injury by hail, frost etc.; the drainage and reclamation of marshy and "alkaline" lands; and similar matters.

GERMANY.

PRUSSIA.

All public operations concerned with the reclamation of land, whether by irrigation, drainage, or the regulation of water courses, are under the supervision and control of the ministry of agriculture, domains, and forests, and are executed by the Prussian reclamation service (Landes Meliorations-Bureau) of the department. When, however, the project affects a navigable river or stream, the matter comes within the jurisdiction of the ministry of public works, and the operations are conducted under the joint supervision of the two ministries.

For the promotion of reclamation work in general, two funds are provided for in the budget of the ministry of agriculture; one of \$119,000 for reconnaissance, preliminary work, and administration; the other of \$166,000 for contributions toward improvements undertaken by water associations and communes. These funds are distributed by the minister of agriculture at his discretion.

These sums have for some time been quite inadequate, and the yearly expenditure of the Prussian ministry of agriculture upon reclamation work is many times greater. The officials of the Meliorations-Bureau number 182, comprising a consulting board of 14 members, an office force of 16, 45 traveling inspectors, and 107 subordinate officers. The estimated expenses of the bureau for the year 1907 were as follows:

Administration, including traveling expenses of officials.....	\$272, 285
Supervision and maintenance, reconnaissance and preliminary work.....	453, 275
Special contributions toward construction work by water associations and communes.....	1, 395, 465

Total expenditure of the ministry of agriculture in reclamation work for the year 1907.....	2, 121, 025
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When reclamation work is contemplated, the course of procedure is as follows:

The persons directly interested lay the case before the local authorities, village or town council, and these, after investigation and approval, bring the project to the attention of the ministry of agriculture, which in its turn appoints one of the officials of the Meliorations-Bureau to make an examination and report. If the official report is favorable, preliminary plans, with estimates of costs, are drawn up by the bureau and submitted to the district concerned for discussion by all interested. Should it be decided that the work is to be undertaken if possible, the next step is to agree as to the partition of the estimated cost of the undertaking. As regards this there is no fixed rule, each case being considered on its merits, the standard partition, however, being an equalization between the State, the province, and the commune or association interested. Should, however, one of the three parties be benefited more than the others, the contribution of that party is proportionately increased. Thus, in the regulation of the River Ahr, a tributary of the Rhine at Coblenz, in the Bodendorf district, by which the State was the greatest gainer, the costs were assessed as follows: State, 50.6 per cent; province, 25.4 per cent; and commune 24 per cent; while in the regulation of the same stream in the Liers and Hoeningen districts, in which the

landholders were the chief beneficiaries, the assessment was: State, 39 per cent; province, 19.5 per cent; and association, 41.5 per cent.

An association (Genossenschaft) of landholders, farmers, and others directly interested in the undertaking is then formed, according to the provisions of the water associations statute of 1879, which regulates the constitution, management, and operations of all such associations, and provides for the individual assessment of the cost of the undertaking, such assessment being calculated according to the area affected and the estimated benefit to be derived from the improvements, the land being classified for this purpose by inspectors under the control of the Meliorations-Bureau, but appointed by the president of the water association. The association undertakes to carry out the construction work under the supervision of the bureau, and in accordance with the plans approved by the officials thereof; and in case of departure from the officially approved plans, to make all alterations required at its own expense. The association is furthermore required to maintain the improvements in such a manner as shall satisfy the inspectors of the Meliorations-Bureau, who are required to make regular examinations of all existing reclamation works. These inspections are supposed to take place yearly, but owing to the number of such works in operation, do not in practice occur much more frequently than every third year.

The project is now ready for the consideration of the minister of agriculture, who, as stated above, can use his discretion as to the extent to which the department shall contribute; the Prussian Government is, however, inclined to act liberally in such matters, especially where associations composed of small farmers and peasants apply for assistance; where larger projects, involving the expenditure of considerable sums, are under consideration, application must be made both to the Landtag of the province and of the State for a special appropriation.

The contributions, both of the State and of the province, almost invariably take the form of a bounty. In exceptional cases sums of money, either separately or in addition to the bounty, have been lent to associations and communes for a long term of years, either without interest or at a low rate, rarely over 2 per cent per annum.

As stated above, the water association is required to maintain the works in good condition at its own expense; but the supervision and control remain permanently in the Meliorations-Bureau.

In the year 1906 there were in the State of Prussia 4,500 water associations, classified as irrigation, drainage, and dike associations, operating over 7,922,166 acres, as follows:

Water Associations in Prussia.

Irrigation and river improvement associations:

Number	2,400
Area operated	3,212,357 acres
Cost of improvements	\$32,130,000
Cost per acre	\$10

Drainage associations:

Number	1,400
Area operated	756,139 acres
Cost of improvements	\$13,209,000
Cost per acre	\$17.47

Dike associations:

Number.....	700
Area operated.....acres.....	39, 953, 670
Cost of improvements.....	\$41, 293, 000
Cost per acre.....	\$10. 44

Total cost of improvements, \$86,632,000.

In Germany, owing to the regular and abundant rainfall, irrigation is not a matter of such economic importance as in central and southern France and in Italy, and there are in consequence no systems of the same magnitude as those in operation in these countries. In fact, the reclamation problem, as it exists in Prussia, is rather to relieve the arable land, by surface modification and drainage, of excessive moisture during periods of humidity than to provide additional water supply; the chief object of irrigation appears to be the flooding of meadow lands in the late autumn and winter, and also in early summer when necessary.

In this regard the irrigation works now in course of construction at Thedinghausen, Syke, and Bruchhausen, commanding an area of 11,525 acres, situated within a bend of the River Weser, are of interest. Various schemes for flooding this low-lying meadow land had been put in operation from the end of the seventeenth century, but after various vicissitudes the project was abandoned in 1848. The present plan embodies a main canal about 16.7 miles long, the intake being by means of a sluice directly from the Weser, the previous weir construction having proved impracticable, owing to the broken ice carried down the river in the spring. A number of distributaries are supplied from the main canal, and those are furnished with checks at varying intervals, whereby the water is backed up for certain distances and the water delivered through laterals and sluices over 55 sections of meadow land, averaging 185.25 acres each. Owing, however, to the extreme porosity of the sandy soil to which the water is furnished, and the uncertainty of the supply from the river, the project has hitherto failed to answer the expectations formed of it.

To the north of the city of Bremen an extensive diking, draining, and irrigation system, covering some 500 acres, is carried on, partly by the city and partly by an association formed for the purpose, the cost of construction and expense of maintenance being divided between the city and the association. The water is supplied from the River Wumme, a tributary of the Weser, and into this river the sewage of the city, after passing through a series of clearing and settling basins, is pumped.

The most notable example of reclamation work in north Germany is the extensive project known as the diking and unwatering of the Memel Delta, an alluvial accretion lying between the embouchures of the Russ and Gilge rivers, which has for centuries been subject to periodical flooding both from the overflow of the rivers and from the backing up of the waters of the Kurisches Haff, an inlet of the Baltic. The first attempts to reclaim any part of the delta date from the first quarter of the seventeenth century, when the construction of a dike along the banks of the Gilge was commenced, and were continued more or less ineffectually up to the middle of the nineteenth century, when the associations representing the interests of the dwellers between the Russ and Gilge were placed upon a practical

basis; and since then the work of protection and reclamation has gone on with little interruption, until at the end of 1901 the four principal dike unions of the southern district included a reclaimed area of 65,700 acres. The oldest and most important of these associations, the Linkuhnen-Seckenburger Verband, has a continuous existence since 1613, and includes about 55,000 acres; the association operates 7 unwatering stations (using both rotary pumps and water wheels), and maintains 24.3 miles of river dikes, 6.3 miles of sea wall along the shore of the Kurisches Haff, and 29.1 miles of drainage canals within the area operated.

The Memel Delta proper lies north of the Linkuhnen-Seckenburger district and embraces an area of nearly 100,000 acres between the Russ and the Gilge. Of this area about 45,000 acres are included within the dikes of the "Stromdeichverband des Memeldeltas," an organization formed in 1897, which has united in one association the various reclamation enterprises of the delta. The Russ dike is about 17 miles, the Gilge dike (right bank) about 20 miles long. The dimensions of the dikes within the delta are as follows:

Crown of dike, from 23 to 42 inches above highest recorded flood level.
Width of crown proper, 12.46 feet.
Width of crown, when used as a public highway, 18 feet.
Slope on inside, 2 to 1; on outside, 3 to 1.

Along the edge of the Kurisches Haff a sea dike, called the "Haffstaudeich," was built in 1895-96, thus completing the triangular inclosure of the delta. The dimensions of the dike are as follows:

Average width of crown, 6 feet 6 inches.
Width of crown near Karlsdorf, 14 feet 9 inches.
Slope on the land side, 2 to 1; on the sea side, 3 to 1.
Height of crown at Karlsdorf, 12.23 feet.
Average height of crown, 6.56 feet.

The Haff dike starts from the end of the Gilge dike at Karlsdorf and terminates about $1\frac{1}{2}$ miles below the Russ dike, at the northern corner of the delta. For the first 4 kilometers it is constructed of a sandy clay, found in the neighborhood of the Gilge at Karlsdorf; for the rest of the distance the only available material was sand, and this was protected on the sea side with a facing of clay, about 20 inches thick, the clay being applied in slabs and rammed in, the pitching being finished as smooth as possible; the crown and inner slope are either sodded lengthwise with sods taken from the surrounding meadows, or overlaid with a thin covering of clay and sown with grass seed.

It was estimated that the unwatering of the submerged and partially submerged land within the delta (an area, as stated above, of about 45,000 acres) would require the withdrawal of 0.65 liter per hectare per second; this for the 18,500 hectares affected, would amount to 12.02 cubic meters, or 424.74 cusecs. The experiences of the Linkuhnen-Seckenburg Association in connection with the unwatering of that district, caused the engineers in charge of the Memel Delta to recommend the installation of six water elevators at first, each with a maximum capacity of 1.7 cu. m. per sec. (60 cusecs.), and to defer the installation of other machines until the lifting powers of these had been thoroughly tested.

The type of machine decided upon was the scoop or shovel wheel, a modern modification of the Persian wheel, a type which had been in use for many years in Holland. During the preceding twenty years several of these wheels had been set up in various parts of Germany, and a superiority over other elevators for a short lift of water was claimed for them by the constructors. The diameter of the wheels is 8 meters (26.24 feet), width 1.68 meters (5.51 feet); there are 28 shovels. The wheel is driven by electricity and makes 2.6 revolutions per minute.

SAXE-COBURG AND GOTHA.

In this duchy no irrigation works are undertaken by the Government, but in exceptional cases the Government will make advances to the persons desirous of carrying out a reclamation project of approved utility, at a low rate of interest—from $2\frac{1}{2}$ to 3 per cent. Only meadow land is irrigated. There are no statistics available.

WURTEMBERG.

All irrigation and drainage works are constructed under the supervision of the department of agriculture by associations formed for the purpose. If the Government finds that the project is of public benefit, it may contribute a proportion not exceeding one-fourth of the cost of construction as a gift. The total annual contribution of the Government does not exceed \$6,000.

The total cost of the irrigation and drainage works constructed in Wurttemberg during the seven years 1900 to 1906, amounted to \$207,250, an average of about \$2,967 yearly.

ITALY.

GENERAL STATEMENT.

Reclamation work in Italy, whether by irrigation or drainage, is under the supervision and control of the ministry of public works, operating in agreement with the ministry of agriculture.

All reclamation projects are subject to the provisions of the reclamation and drainage law of 1900. According to this statute reclamation operations are divided into two categories, as follows:

First category: (a) All works having hygienic improvement for their principal object; (b) all works combining agricultural and hygienic improvement.

Second category: All reclamation work not included in the first category.

Reclamation work of the first category is executed either (1) by the Government, (2) by licensees approved by the ministry of public works, (3) by the provinces or communes, or (4) by the landholders themselves, who shall form themselves into an association after the manner prescribed by the irrigation law of 1873 and be subject to the provisions of said law.

All works when constructed shall be maintained at the expense of the association of landholders.

The partition of the cost of construction of works of the first category is as follows: Government, three-fifths; province or provinces interested, one-tenth; commune or communes interested, one-tenth; association of landholders, one-fifth of the actual cost of construction. Within this category are included such works as the draining of the Pontine marshes, to be constructed within the years 1906-1915, at a cost of \$500,000 (of which the Government contributes \$300,000; the Province of Rome, \$50,000; the communes, \$50,000; and the landholders \$100,000), and 15 other works of similar character at present under construction, the estimated cost of which amounts to \$6,520,000.

Although the Government may, if it so choose, execute the reclamation works, in practice these are carried out by contractors or by the licensees, who furnish adequate security for the proper execution of their contracts. All working plans, specifications, etc., must be approved by the minister with the consent of the board of public works and of the council of state. The *Genio Civile*, or board of engineers, must ascertain the conditions of the project and pass upon the plans and estimates. For this service the board of public works charges a fee in accordance with the provisions of the law of 1900.

The respective contributions of the Government, the province, commune, and association having been determined according to the estimated cost of the enterprise, are divided into equal installments, not less than 5 nor more than 30 in number, and payable yearly, the first installment to be due upon the 1st day of July subsequent to the signing of the contract for the construction of the works. The number of the installments shall be fixed by the minister of public works, after consultation with the board of works and the council of state and with the agreement of the minister of the treasury. A final readjustment of the amounts payable shall be made upon the completion of the works, upon the basis of the actual cost thereof.

To meet their annual contributions the provinces and communes shall deliver annual warrants against their direct revenues. To meet the contributions of the individual landholders a special tax shall be imposed upon the private lands within the area to be reclaimed, which shall be a lien upon the land and shall be collected by the Government until the debt is liquidated.

A commission presided over by the prefect of the province and consisting of one representative of the province, two delegates from the interested communes, one representative of the provincial board of health, and two delegates from the association of landholders, shall visit the works in course of construction and shall make a yearly report upon their progress and condition to the ministry of public works.

When presenting his budget to parliament, the minister of public works shall make a report upon the condition of all the reclamation works in the Kingdom.

In cases of expropriation, appraisement of indemnification, damage of any kind, evaluation shall be made by three arbitrators, one of whom is appointed by the minister of public works, one by the owner or owners of the lands, and one by the president of the territorial court of appeals. The latter shall also appoint the arbitrator to represent the owners, should these parties fail to do so within the time specified.

Reclamation work of the second category may be undertaken either by voluntary syndicates or compulsory associations. Voluntary syndicates are formed with the consent of all parties interested. They are commercial enterprises and may not claim any benefaction from the Government, province, or commune, but must submit their project to the ministry of public works, and the board of engineers passes upon the same as in the case of works of the first category. All construction work must meet with the approval of the board of engineers.

Should the enterprise be beneficial to hygiene and also be of advantage to agriculture, a voluntary syndicate may, two years after its formation, demand to be changed into a compulsory association. In order to effect this change the consent of the provincial and communal councils is necessary.

The expense of construction, carried out by the compulsory association thus formed, is distributed as follows: Government, one-tenth; province, one-tenth; commune, one-tenth; and association, seven-tenths.

When the project is completed the Government, province, and commune may claim the reimbursement of their respective contributions. This refund shall be divided into not less than ten annual installments, without interest.

A reclamation project is considered completed when the works contemplated by the approved plans have been executed and the land is fit for cultivation. The decision as to the completion of a project is made by a commission appointed by the minister of public works and composed of an inspector of the geological survey, the chief engineer of the geological survey for the province in which the work is situated, a member of the provincial board of health and an official of the ministry of agriculture. The project being declared completed, the minister of public works may, if necessary, require the landholders to form an association for the maintenance and administration of the works.

The estimated increase in revenue from the lands reclaimed is exempt from real estate tax for a period of twenty years from the date of the intended completion of the work.

The combined report of the minister of public works, the minister of agriculture, and the minister of the treasury for 1900 furnishes the following statement of the reclamation work in progress and contemplated between 1900 and 1924.

I. Reclamation work of the first category, under construction: Nineteen projects; total cost, as estimated, \$12,700,000, of which \$10,625,000 falls upon the government, the provinces, and communes.

II. Reclamation work under construction by syndicates: Ten projects; total estimated cost, \$5,970,500.

III. Reclamation work of the first category, approved by the government, but not yet under construction: Seventy-one projects; total estimated cost, \$23,844,800, of which \$19,075,940 are to be borne by the government, provinces, and communes.

A special appropriation of \$40,000 annually is made for the purpose of studying the conditions of the various reclamation projects submitted to the ministry of public works.

IRRIGATION IN NORTHWESTERN ITALY.

Irrigation in northwestern Italy is almost entirely dependent upon the River Po and its many tributaries, which cover the great plain of Piedmont and Lombardy with a network of streams, rendering possible a most complete system of irrigation. The unbroken chain of mountains which bound three sides of the provinces furnish through the perpetual melting of the snow masses that clothe their upper slopes, an inexhaustible supply of fertilizing water to the plains beneath, and feed, in the mountain valleys, numberless rivulets that are used to irrigate the fields and meadows up to the edge of the snow line.

Three main systems of irrigation are practised in this region: Firstly, the distribution of water by means of canals and laterals to districts not irrigable by the small streams; secondly, the sustentation of those streams whose flow is subject to wide variation by water from other streams that do not fluctuate similarly, by means of connecting conduits; thirdly, the furnishing to the soil ingredients productive of fertility in which it happens to be lacking, such as the conveying of water turbid with clay to lands that are loose and friable, and contrariwise, water holding sand in suspension to soils that are naturally too stiff.

During its course from its source at Monviso in the Graian Alps to the sea, the Po receives 15 tributaries; on the right bank, the Maira and Varaita from the Maritime Alps, and on the left bank the Pellice, Sangone, Dora Riparia and Stura from the Cossian Alps, the Malone and Orco from the Graian Alps; the Dora Baltea and Sesia from the Graian and Pennine Alps; and the Agogna, Terdoppio and Ticino from the Lepontine Alps. The characteristics of all these rivers, both as regards the periods of their fluctuations, and the soil they carry in suspension, have been carefully studied for many years, and the result is a system of interchange of water supply of the most complex character. The tributaries are classed as either sand-bearing, to which class belong the Dora Riparia, the Dora Baltea and the Ticino; or clay-bearing, which includes the rest of the tributaries. The three first-named rivers are also defined as summer-flow rivers, having their sources in the higher Alps, where the snow only begins to melt toward the end of spring, and are in flood from May till September; while the others, styled winter-flow rivers, which rise among the foothills and at the edges of the great Italian plain, where the winter rains are frequent in the valleys and the snow melts from the hills as soon as winter is over, are in flood during winter and spring and fall off steadily all through the summer. The following table shows the comparative variations:

Variation in stream flow.

	October- May.	June-Sep- tember.
Summer streams:	<i>Cusecs.</i>	<i>Cusecs.</i>
Dora Baltea.....	1,400	5,600
Winter streams:		
Po at Chivasso.....	3,175	2,120
Sesia (and affluents).....	1,765	706

Owing to these conditions, it is possible, except upon rare occasions, such as the drought of 1882, when the flow of the Po at Chivasso went down to 990 cusecs for fifteen days, to maintain a normal and regular delivery of water throughout the irrigating season.

The great canals of the Piedmont-Lombardy district, between the Po and the Ticino, are under government control, the system being termed the Canal Demaniali. The principal canals are:

Principal canals of Piedmont-Lombardy district.

	Flow in cusecs.
Cavour Canal.....	3, 885
Depretis Canal.....	1, 950
Sartirana Canal.....	882
d' Ivrea Canal.....	706

The total discharge of the canals of the system is 10,240 cusecs.

Of all these the Cavour Canal (so named after the famous patriot and statesman) is the most important. It issues from the Po a short distance below Chivasso and after a course of 50 miles discharges into the Ticino. It is constructed of stone and concrete throughout its whole length; the width of the bed of the canal is 65.5 feet; it is carried in aqueducts over the Dora Baltea, the Cervo, the Roasenda, and Marchiazza rivers and in syphons beneath the Elvo, Sesia, Agogna, and Terdoppio. The project was started in 1846, and after many delays construction began in 1863. The canal was declared open in 1867. The total cost of the canal was about \$16,000,000.

The Depretis Canal comes next in capacity to Cavour, having a flow of 1,950 cusecs. This canal was constructed in 1785. It is taken out of the Po below Villareggio, and discharges into the Elvo.

The Ivrea Canal is one of the oldest in Piedmont. It was opened in 1468, during the regency of Yolande of Savoy, and abandoned a century later, its channel having become choked with silt. In this condition it passed in the seventeenth century into the possession of the Princess of Villafranca, who restored it, and it was regularly used both for irrigation and navigation up to the year 1820, when the State purchased it back from the private holders. Its course is 46 miles.

The more important affluents of the Po are discussed below:

The Dora Riparia supplies 21 canals between Villafocchiardo and Turin, and also furnishes motive power to the chief industries of the towns along its banks. The flow of the Dora Riparia (a summer-flow stream) is subject to great fluctuations, and this is the cause of considerable inconvenience both to the irrigation and industrial interests. Many suggestions have been made with the object of regulating the flow of the stream, but none have proved practical. The area irrigated is about 20,000 acres, and the discharge varies between 1,050 cusecs maximum and 525 cusecs minimum. In periods of drought the discharge falls as low as 350 cusecs.

The Stura di Lanzo supplies 10 canals, 3 from the right bank and 7 from the left. Motive power is also supplied to several towns.

The Dora Baltea, being the strongest of the summer-flow streams, is called upon to make up the deficiency of the other rivers during the summer. It effects this by means of three canals—the Ivrea, capacity 1,942 cusecs; the Rotto, 1,900 cusecs; and the Farini, 2,471 cusecs.

The Ticino supplies the Grand Canal (a navigation canal) between Milan and Pavia, and three irrigating canals, of which the Langosto, with a flow of 635 cusecs, irrigates 30,000 acres, and the Sforzesco, with a flow of 555 cusecs, 25,000 acres.

Another irrigating device is the lift pump, by which water is driven up a vertical shaft of considerable length. The Cigliano shaft is 131 feet in height, and irrigates 3,750 acres; the motors of the pump are driven by the Depretis Canal, and the water is taken from the Ivrea Canal; the flow is 45 cusecs.

The Government supplies water for irrigation at the following average rates:

- (a) For the summer season, 2,500 lire (\$445.90) per second-hectoliter (3.53 cusecs).
- (b) For the winter season, 180 lire (\$34.74) per second-hectoliter. Or
- (c) For the rice fields, 100 lire (\$19.50) per hectare=\$7.80 per acre.
- (d) For meadows or marcite,^a 60 lire (\$11.70) per hectare=\$4.68 per acre.

All the irrigating systems in northwestern Italy, except those constructed by private capital for use upon private property, are under the control of the Central Government.

No account of the irrigation system of the basin of the Po is at all complete without some mention of the irrigation association of the West of the Sesia, which was instituted in 1854. Previous to this date, the water users living within the district suffered considerably from the conflicts of interests between rival ditch owners, the conflict between Government and private canals, the uncertainty of water supply, and the unstable character of the charges for water. Speculation in water was rife, and formed one of the most objectionable features of the old system, and in this conflict the water user was always the loser. In order to bring conformity into the system of water supply, and to remove the opportunities for extortion which accompanied any shortage of water, Count Cavour and the distinguished engineer Carlo Noé formulated a proposition to unite all the water users between the Dora Baltea and the Sesia into a co-operative association. This was a proposition fraught at those times with many difficulties, and hindrances of all kinds were encountered; but the determination of the Count and the enthusiasm and ingenuity of the engineer finally triumphed and the association of water users was finally organized in January, 1854. Since that date the zone and the activities of the association have steadily increased. In 1902 it controlled a territory of about 56,000 hectares (nearly 140,000 acres) and supplied water to 40 different Consorzi, or syndicates of water users. The association purchases water at a contract price from the State and privately owned canals, and distributes it throughout the territory controlled at cost price, with a small addition for expenses of management.

Great as are the benefits conferred upon the cultivator by this so-called cooperative system, the Government deems it matter for regret that, owing to the varying conditions in different parts of the district controlled, the prices of water vary very considerably, as also the charges for management, so much so as to be in some places

^a Marcite, a mixture of clover and rye. It yields six to ten cuttings a year.

four times as high as in others. The State would prefer to see the association reconstructed upon a "confederated" foundation, which would be in effect more truly cooperative than the present one, whereby the whole of the water supplied to the association would be distributed equitably over the whole district and the cost thereof, together with the working expenses, assessed according to the area irrigated and the character of the crop raised, instead of, as at present, according to the effective consumption of water. But as the present constitution and contracts of the association, renewed in 1884, do not expire until 1914, no change can be looked for till after that date.

Operating in a similar manner to the West of the Sesia association, but basing its assessment charges upon the area irrigated and class of crop, is the *Consortio*, or League of Cavo Montebello, which commands about 13,000 acres and includes nine communes within its periphery. In apportioning the water charges in this association, the following proportions are observed. Per irrigation; field crops: meadows : rice-fields : : 1 : 3 : 7.

Before the season opens, the acreage to be allotted to each class of crop is definitely fixed, in order that the association may make its requisition for water of the Government, which furnishes the needed supply to the *Consortio* at a discount of 20 per cent.

THE NETHERLANDS.

GENERAL STATEMENT.

In no country does the reclamation of the land occupy so important a place in the national economics as in the Netherlands. From the earliest times the dwellers in the "hollow land"—more than one-half of Holland is below mean sea level—have been compelled in self-defense to raise barriers of some sort or other against the perpetual menace of the ocean, and for the last 600 years the protection of the seaboard has been one of the chief cares of the rulers of the State, while construction of the barriers themselves has gradually advanced from the rude appliances of mediæval times to the latest development of the science of modern engineering. The prosperity of the country depends more directly than on anything else upon the successful defense of the coast against the onset of the sea, and nearly one-fifth of the revenues of the Kingdom is appropriated to that end every year in the budget of the department of the waterstaat, to whose care is intrusted the supervision and maintenance of the whole system of dikes, waterways, and drainage of the country. This remarkable system, whereby the ingenuity and perseverance of the Dutch race have succeeded in transforming the lowlands of the country from malarial morasses into one of the most fertile and valuable agricultural districts in Europe,^a merits a detailed description.

Along the greater part of the coast the sea itself, under the influence of wind and tide, has thrown up a natural barrier of sand above high-water mark. On these ridges grass has grown and gradual accretions

^a The prices of cultivable land in Holland are surprising. The "bulb land" south of Haarlem rents at \$60 to \$80 an acre, and sells for \$1,600 to \$1,800 per acre; the market value of ordinary agricultural land in Friesland is from \$200 to \$220 per acre; the raw land reclaimed from the Y polders, when the North Sea Canal was constructed, sold at auction as high as \$540 per acre.

of soil and sand have raised the dunes higher and higher until lines of sandy hummocks, sparsely covered with herbage and stunted shrubby growth, rising from 30 to 50 feet above the level of the ocean, and from a few hundred feet to more than a mile in width, extend along the greater portion of the western coast, and effectually protect it against the encroachments of the sea. But along the northern coast and the shore line of the provinces bordering the Zuider Zee, and of the islands and Zeeland in south Holland, and generally throughout the deltaic district, this natural protection is frequently absent and the sea is kept out by means of dikes. These are generally built up of material in situ, sand, gravel, or earth; the surface is planted thickly with willow withes; these are closely interwoven, and by filling the interstices with clay the whole is compacted into a consistent surface, turf being also frequently used for the same purpose. The seaward slope of the dikes, or at any rate all of the surface thereof that comes in contact with the sea, is faced with blocks of basalt or Norwegian granite set on edge and fitted closely together so as to present as smooth a surface as possible to the water. This banquette, whose slope is very gradual, frequently extends several hundred feet seaward and to a considerable depth.

In races and other points exposed to violent wave action various means are adopted to prevent erosion. Quadruple rows of piles are driven seaward in order to break the force of the current; breakwaters formed of large blocks of basalt or concrete are carried out from the head of the banquette; rows of piles are driven parallel with the toe of the dike, and in some places called "zinkstukken," or sinking places, the weak foundation is strengthened by a mattress work, the willow crates of which are packed with rubble. In spite, however, of every means employed, scouring along the toe of these dikes continues and their maintenance calls for continual watching and repair.

The largest sea dikes in the country are those at Helder and Petten in north Holland and at Capelle, on the west coast of the island of Walcheren. The Helder dike is 5 miles long, 12 feet wide at the crown, and protected by a wide banquette which descends into the sea for a distance of 200 feet. The dike is further strengthened by huge concrete bulwarks or breakwaters extending several hundred feet into the ocean. This dike is constructed entirely of Norwegian granite, except in some places where concrete blocks, owing to their greater power of resisting wave action, have been substituted.

The Capelle dike is 12,486 feet long, 23 feet high, and 39 feet wide at the crown. The seaward slope is 300 feet wide. The toe of the dike is protected by parallel lines of piles and blocks of basalt.

There are in the province of Zeeland certain districts whose dikes from various causes require special attention and which if breached or allowed to become in anyway defective, would be a menace to a large extent of country. The polders of these dikes are called "kalamiteuze polders," and as the burden of maintaining these "calamitous" dikes is too great to be entirely borne by the district they directly conserve, their control is placed in the hands of the State and special appropriations are made for their maintenance. It is in this province that the so-called dike rotting and slipping of the banks sometimes takes place. In former times serious breaches in

such dikes, and consequent damage to the surrounding country, were not infrequent; but of late years owing to increased precautions and improved methods of repair it is only in very exceptional circumstances, such as those which attended the great storm and flood of March 12, 1906, that a break occurs, and even on this occasion, when an extraordinarily high spring tide and a terrific gale combined to hurl the full force of the North Sea against the already weakened barrier, not more than one fortieth of the total area of the province of Zeeland was inundated, while the damage to other provinces was but trifling. Upon the maintenance of the dikes the department of public works (waterstaat) expends about two and a half millions of dollars annually.

The protection of the coast line once effected, the next step in the reclamation of the country was the embanking of the rivers, themselves for long a serious menace to the surrounding districts at seasons of high tide or in stormy weather when their waters, driven back upon themselves, would overflow their banks and turn the country for miles around into an arm of the sea. At the present day all the rivers in Holland are "normalized," and flow between corrected banks. The most important "correction" of the course of a stream was the turning of the mouth of the Maas or Meuse, from Woudrichem to Geertruidenburg, during the years 1884-1904, whereby the draining of a large portion of the province of North Brabant was greatly facilitated. In addition to the normalization of the great rivers, all smaller navigable streams are canalized, and thus connected with the great inland waterway system of the country.

The whole of the lowland of Holland is intersected by canals, which serve to carry off the "inner waters" and as highways of traffic. The length of the canals was nearly 2,000 miles in 1907, exceeding that of the rivers of the country, and to this figure must be added 1,000 miles of navigable streams. The regular width of the canals is 60 feet and depth 6 feet. The current and discharge are regulated by means of locks and sluices.

The problem of land reclamation in the Netherlands has always been of twofold character. The "outer waters" have to be repelled from the land, and the "inner waters" expelled to the ocean. And this work of repelling the "outer" and expelling the "inner" waters goes on continually. For, owing partly to the porous character of the soil, partly also to the lack of natural drainage in the low-lying districts, and the consequent difficulty of removing the superfluous rainfall, the unwatering of the country has been a matter calling for the utmost skill, ingenuity, and perseverance. The canals themselves, originally constructed with a view to the draining of the district, have upon occasion proved highly dangerous when unable to discharge their waters, and from the beginning of the fifteenth century (in the year 1408 we have the first mention of a windmill erected for the purpose of pumping out water) artificial means of one kind or another have been employed to raise the continually accumulating water from the low-lying lands and discharge it into the ocean. Windmills of one kind or another continue to be the power most used in pumping out water in small quantities, as many as 3,100 being now in use. The first steam pump was set up near Rotterdam in 1787, and their use has steadily increased. The last issue of the water-chart gives the number of steam-power water mills as 260,

representing 11,000 horsepower. It will be fair to assume that since the publication of that chart about 20 more steam mills have been installed, so that their number at present would be about 280, with a total of 13,000 horsepower. A particular sort of electrical water mill is in use at Raamsdonk and Dussen in North Brabant, and the power for the pumps at Neukirch, which unwater the low-lying polders along the corrected embouchure of the Meuse, is supplied by two electric-power stations.

The system by which the reclamation of land is accomplished and maintained, and which, as has been shown, is a combination of dikes, canals, drains, and pumping mechanism, is termed "impoldering." So universal is this system throughout the low-lying portions of the country that the west of Holland has been called one gigantic "polder."

The manner in which a "polder," which may be of any size from a few acres up to 300 or 400 square miles in extent, is formed, is as follows:

The portion of land selected for "impoldering" is first surrounded completely by a dike, which shuts out the "outer water;" and by taking all the earth for the dike from the inside of the polder, a trench varying in size according to the dimensions of the dike is formed, which serves both as a drainage ditch and as a reservoir out of which the "inner water" is raised into the main canal, and thus carried to the ocean. Whatever the size of the polder, the principle is the same; except that when the level of the polder is too far below that of the main canal to admit of the water being raised thereto in one operation, a series of dikes is built, each with its encircling canal, and the water being raised from one to the other finally reaches the main channel of discharge.

It must be remembered that, owing to the high infiltration of the sandy soil, and the previously enumerated causes, this process of unwatering must be systematically continued, if the polder is to be kept in a cultivable condition. In some districts the infiltration is so great that even with regular pumping the polder becomes waterlogged, and often becomes a source of danger to the surrounding district. A notable case of this kind occurred quite lately when the Maas embouchure was deflected to Geertruidenburg, the pressure of the water in the new channel caused such excessive infiltration in the adjoining polders, that two electric-power stations had to be established in order to drive the centrifugal pumps set up for the purpose of draining the threatened polders.

In order that the management and maintenance of the polders may not be left to individual responsibility or haphazard action, each polder is placed in control of a Waterschap, or board, which is responsible to the governor of the province for the condition of the polder in its charge, and has also certain plenary powers of administration and jurisdiction assigned to it. These Waterschappen are subordinated to a superior council (Hooghemraadschap), which has charge of the main waterways and an interprovincial jurisdiction, thus acting as a check upon the local Waterschappen and preventing them from overburdening the main channels and waterways.

But the inhabitants of Holland have not been satisfied with merely defending their country against the threatened encroachment of the

ocean; they have set out to capture territory from the sea itself, and so successful have been their campaigns that during the last seventy-five years the area of the Netherlands has increased nearly 50 per cent; that is, from 8,768 square miles in 1833 to 12,648 square miles in 1906. And these accretions are still going on, particularly along the coast of Zeeland, Friesland, and Croningen, where the shore is very flat and the "slikken" or mounds of sea clay gather sea grasses which in process of growth elevate them slightly above the sea level, when they are termed "kwelders" or grass banks. When this stage is reached, the watchful inhabitants (who, for that matter, frequently assist the process of "kwelderizing" by covering the "slikken" with wattles of straw) throw out a dike, impound the "kwelder," drain the marsh, and turn the once slimy seashore into a revenue-producing polder. Thirty-eight square miles of territory have been thus added to the northern provinces since 1877, and the contemplated inclosing and draining of the Zuider Zee, the greatest enterprise of its kind ever contemplated, will, if successfully carried out, add nearly 1,500 square miles to the area of the Netherlands.

The best example of impoldering on a large scale, being also the largest undertaking of the sort in the country, is the unwatering of the Haarlemer Meer, or Lake of Harlem. This body of water, which had been increasing in size for centuries—in 1531 it covered about 6,000 acres, and three adjoining lagoons spread over a yet larger area—was by the year 1830 nearly 40,000 acres in extent. The high tides of 1836 caused a disastrous flood which covered almost the entire country between Amsterdam and Leyden, and the continued existence of this inland sea was a menace to the State which could no longer be disregarded. As early as the seventeenth century a hydraulic engineer named Leeghwater had put forward a plan for draining the lake (then only 17,000 acres in extent) by means of 160 windmills, and the commission which was intrusted with the work after the flood of 1836 adopted a plan which did not essentially differ from Leeghwater's, substituting, however, steam power for wind. When the unwatering operations began in 1848 the area of the lake was over 45,000 acres, with a water content of about 800,000,000 tons, which was continually receiving accretion through infiltration.

The work of impoldering followed the usual course, the magnitude of the task alone differentiating it from others of a similar character. A canal 40 miles in length was built round the lake, and the excavated earth went to form the inclosing dike. The outlets to the ocean were closed by earthen dams, and the work of pumping out the water was begun. Three steam engines, specially manufactured in England for the purpose, each capable of pumping out 1,000,000 tons of water in twenty-five hours, were set in place at different points of the canal, and on May 12, 1848, the pumping began.

The contents of the lake were estimated at 800,000,000 tons (23,673,611,111 cubic feet, taking the ton at 55,455 cubic inches), and the engines, with their capacity of 350 cusecs, would have drained it in little more than two years, barring accidents, were it not for the continual infiltration from the ocean. It was not until July 1, 1852, however, that the lake was officially declared to be unwatered. But the engines are still at work, for the seepage is a continual menace and, moreover, the polder is lower in the center than at the sides, and

requires to be pumped out after every rain. The amount of water annually pumped out averages 54,000,000 tons.

The cost of the ring canal and dike was \$778,640. The engines and their operation cost \$973,300. The polder is traversed by two main canals, each 80 feet wide; six smaller ones cross the breadth of it and four the length. The polder contains 130 miles of roads, and the canals are spanned by 70 bridges. The total outlay on the work was \$3,893,200.

The area of the land reclaimed by this gigantic operation was 41,675 acres. While the work was still in progress an offer was received from a foreign syndicate to purchase the whole polder at \$48.66 per acre. As the price realized for land similarly reclaimed had been, at the latest sale, less than \$30 an acre, the offer was considered a satisfactory one and would probably have been accepted had not the city of Leyden intervened with a claim of territorial rights over the property. The ensuing uncertainty as to title protracted the negotiations, and finally it was decided, a year after the polder had been drained, to hold a public sale of about 2,000 acres. Before the day of the sale the city of Leyden lodged a protest against the proceedings and purchasers were threatened with ejectment proceedings if they attempted to settle on the lands. In these circumstances the Government of the Netherlands intervened and undertook to furnish all purchasers with a warranty of peaceful possession. The sale then took place and the land realized \$120.84 per acre, or two and a half times as much as the syndicate had offered.

This enterprise was the most successful of its kind, the land, proving of excellent quality, having since then risen considerably in value. A much higher price, it is true, was obtained, as has been previously noted, for the land reclaimed in the construction of the North Sea Canal. The 12,450 acres of the Y polders, as they are called, being close to the city of Amsterdam, sold in part as prospective building land for as much as \$1,654.61 per acre, but even for the agricultural portions more than \$540 per acre was obtained. In general it may be said that of late polder land has fetched so high a price that agricultural industry has been a good deal hampered on account of high value and assessments placed upon the polder meadows.

THE UNWATERING OF THE ZUIDER ZEE.

No account of land reclamation in Holland would be complete without reference to this immense project, which has been at once the dream and the despair of the Dutch hydraulic engineers for the last fifty years, and has become of late so intimate a part of the aspirations of the people that, by some means or other, it will assuredly be accomplished within the present generation. The popular agitation with regard to this scheme has of late years been systematically fostered by the Zuider Zee Vereeniging, or union, which was founded in 1886 with the express purpose of forcing the Government to take action with regard to a measure so earnestly and generally advocated. In 1892 this organization submitted to the Queen Regent a detailed statement of the financial, social, and economic advantages to be gained from the draining of the Zuider Zee, and a state commission consisting of 29 members was consequently appointed later in the year to investigate and report upon the subject.

The commission divided into four sections, representing the following interests concerned: (1) Technical and defensive; (2) economic, agricultural, and financial; (3) waterways and fishery; (4) public health.

The majority report of 21 out of the 29 members (6 members dissented, and the minister of waterstaat did not vote) was made in April, 1894, recommending the project. The objections of the minority were based upon the financial vastness and uncertain outcome of the undertaking, but the commission finally unanimously recommended that the work be done "by the State in the manner covered by the report."

An authoritative work on the project by the two secretaries of the commission was afterwards published, from which the following outline of the scheme is derived:

In the first place, the Zuider Zee is to be cut off from the ocean by a dike 18.006 miles in length, extending from the Ewyk Sluice, in the Province of North Holland, across the island of Wieringen to the Frisian coast at the village of Piaam, the sea thus cut off to be transformed into an inland sweet-water lake to be called the Yssel Meer, consisting of 856,392 acres. From the area of this lake 4 polders, with a combined superficies of 523,430 acres, will be reclaimed in the usual manner, reducing the area of the Yssel Meer to 332,960 acres. The sizes and description of the 4 polders are:

Area and cost of reclaiming the Zuider Zee.

	Total surface.	Arable land.	Cost.
	<i>Acres.</i>	<i>Acres.</i>	
I. Northwest polder.....	53,620	46,207	\$5,105,400
II. Southwest polder.....	77,885	68,742	9,185,700
III. Southeast polder.....	266,275	243,382	24,863,700
IV. Northeast polder.....	125,650	119,832	13,065,000
Total	523,430	478,163	52,219,800

There would thus be added to the Netherlands a twelfth province, which it is proposed to name Wilhelmina, eleven times the size of the Harlem Lake, and more than one-sixteenth of the present area of the Kingdom, and of an estimated value of \$500,000,000.

The entire estimated cost is nearly \$76,000,000 (189,000,000 guilders) and the work will occupy thirty-three years. The dike will cost about \$16,000,000, and the estimate for the rest of the work is \$59,697,000.

No land can be sold during the first sixteen years of the project, but from the seventeenth up to the thirty-sixth year 39,500 acres can be put on the market annually.

The valuation of the work at the end of the thirty-sixth year, at 3 per cent compound interest on the cost, amounts to \$148,867,112.

The time to be occupied in the work is apportioned as follows: Building the sea wall, making harbors, etc., nine years; reclaiming the northwest polder, tenth to fourteenth year; reclaiming the southeast polder, fourteenth to twenty-fourth year; reclaiming the southwest polder, twenty-fourth to twenty-eighth year; reclaiming the northeast polder, twenty-eighth to thirty-third year.

The eminent engineer at the head of the department of public works, Minister Lely, is said to have stated that even if no reclamation or impoldering followed, the construction of the dike alone would justify the expenditure. Floods and devastation have marked the history of the Zuider Zee for centuries, one inundation alone having submerged 40,000 acres and destroyed many prosperous villages.

The Zuider Zee has already nearly 200 miles of dike, the maintenance of which is a constant tax on the public works department. The new dike, running directly across the strait, would be less than 20 miles long, and a great saving in maintenance would be immediately effected. The distance from shore to shore is nearly 35 miles, but by carrying the dike across the island of Wieringen a considerable reduction is made in the length of the sea wall. The dike itself is estimated to require 250,000 piles and 70,000 tons of basalt. The crown of the dike will be 17 feet 8 inches above mean sea level at Amsterdam; the width of the dike will be 7 feet at the crown and 216 feet at sea level. On the land side will be an embankment 56 feet wide for a railway and highroad. The dimensions of the locks at Wieringen are 325 by 33 feet for steamers and sailing ships (but not large enough for battle ships) and 131 by 20 for fishing vessels. The Yssel Meer to be left in the center of the inclosure will receive the waters of the Yssel River.

The estimated expenditure includes, besides the harbor work at Wieringen and elsewhere, the construction of a canal from Ketel to Muiderberg, the improvement of the Zwolsche Diep, and the water supply of Amsterdam. Ten million guilders (\$4,020,000) are set aside for strengthening the national defenses, and \$1,809,000 as indemnity for the fishing trade of the coast of the Zuider Zee.

Out of the area reclaimed there will remain for sale, after the land required for public buildings, schoolhouses, churches, etc., has been deducted, 462,000 acres (192,500 hectares). To recoup the State for the outlay made in connection with the enterprise, it is estimated that the reclaimed land must be sold at the price of \$381.90 per hectare, or \$154 per acre. That this figure is not excessive is evident from a comparison with the present value of agricultural lands in Friesland (\$215 per acre), Zeeland (\$219 per acre), and North Holland (\$300 per acre).

As to the prospect of population, the Harlem Lake polders support an average of 2 persons to each 5 acres. On this basis the commission assumes that the Zuider Zee polders, cut up into agricultural holdings of from 96 to 120 acres, will support 200,000 inhabitants, of whom one-fifth will be agriculturists of from 20 to 60 years of age. These people are to be settled in 8 communes and 40 villages and to occupy 4,000 farms. The cost of administering the new province is estimated at \$322,406, while the revenues are calculated to amount to \$459,486, leaving an annual surplus of \$137,080.

In order to assist the peasant purchasers in acquiring the land, an amortization scheme has been drawn up, which provides for the acquisition of the land by 45 yearly payments of \$8.60 (nearly) per acre, which includes the polder tax.^a

^a All these statistics are taken from the report of the secretaries of the commission of 1892, already referred to.

Her Majesty the Queen, in her address to the last States-General, promised that as soon as possible a law would be promulgated concerning this important subject, and it is probable that this will take place before the end of the year. The department of public works, therefore, states that projects and figures hitherto put forth with relation to the scheme are purely problematical, and have no acknowledged bearing or indication with respect to possible official action in the future.

IRRIGATION IN THE NETHERLANDS.

Irrigation occupies but an inferior place among the factors of agricultural development in Holland. The physical conditions of the western part of the Kingdom, the extreme porosity of the soil in the low-lying districts, the general need for drainage rather than the application of additional moisture, and the network of waterways, which would seriously add to the expense of any scheme of irrigation upon an extended scale, combine to make it more than improbable that the irrigated acreage will ever reach a high figure. It is true that, following the example of Belgium (*q. v.*), several irrigation enterprises were entered upon with considerable zest in and about 1850. Some of these were after awhile abandoned, but others managed to survive, and by the year 1900 there were altogether 1,235 acres under irrigation.

This result has been achieved entirely by individual effort and private enterprise, for the Dutch Government does not extend any direct aid or assistance in connection with irrigation or drainage work, nor are any direct subsidies granted toward the execution of such work.

In the year 1893, however, a royal commission was appointed to discover what lands in the Netherlands were capable of being reclaimed through irrigation and to ascertain whether the Government would advisedly participate in such projects.

The chief outcome of the report of the commission, which appeared in 1896, was the grant of a small yearly subsidy (\$1,600 in 1897, increased subsequently to \$3,618) to the Dutch Heath Company, an association which concerns itself with the reclamation of heath or waste lands.

Under the terms of the grant, the Heath Company undertakes the training of irrigation experts (a two years' course is provided at the experimental station); the advising and drawing up of plans for intending irrigationists; the construction of works; the establishing of small experimental tracts, etc.

Up to the present, 15 irrigation inspectors have been trained by the Heath Company. They reside in different parts of the country, and may be consulted by interested parties upon payment of traveling expenses. Persons desirous of undertaking works for the improvement of land, exclusive of impoldering, are referred by the Government to the Heath Company, which is in statutory charge of all undertakings of this sort. The company will not merely construct irrigation works, but will also maintain and manage them indefinitely, if so desired.

The only parts of Holland where irrigation has any prospect of development are the eastern and southern districts, and the hilly regions, especially such tracts of land as the Luneberg Heath, the Kempen (Campines) on the Dutch side of the Meuse (see under Belgium), the Sieghthal, etc. In North Brabant, also, material success attended the irrigation of about 25 acres near Westerhoven, and in South Willems vaart and the neighborhood, where the irrigation system of the campines taken out of the upper Meuse (Maas) is made use of to some extent, satisfactory results appear to have been attained.

The official organ of the Heath Company (Nederlandsche Heide Maatschappij) for 1905 states that plans are in preparation for the irrigation of about 6,175 acres in the Province of Gelderland on the banks of the Berkel, and according to the same authority an experimental irrigation tract of 9 acres has been laid out at Lochem, and another similar one at Diessen in North Brabant. The company had then laid out about 75 acres of meadow land for flood irrigation, and plans for the preparation of other tracts were under way; but the operations of the company are of so minor a character that the department of public works is justified in summing up the irrigation situation in Holland in these words (taken from one of its reports): "In general, there is no irrigation in the Netherlands."

RUSSIA.

GENERAL STATEMENT.

In European Russia reclamation work is carried on at government expense on crown lands only. Technical assistance is furnished to private landholders at a regular rate. In the case of peasant communities or associations or peasants, the technical charge is remitted.

In the trans-Caspian provinces irrigation work of public benefit receives special aid by means of loans at a low rate of interest and long term of payment, provided from a government fund. All landholders are entitled to make application for government assistance for executing irrigation operations, and all moneys repaid by the borrowers are returnable to the fund, thus making it revolving.

The law concerning government assistance in reclamation operations is in substance as follows:

All expenses in connection with irrigation and drainage works in European Russia are under the direct control of the imperial controller, who administers in accordance with certain regulations issued by the ministry of agriculture in concurrence with the imperial controller, the cost of such control being included in the general cost of the operations.

For the work of preparing plans and estimates and supervising operations a special charge is made by the Government, said charge taking the form of a tax, which is confirmed by the minister of agriculture. This minister is empowered to make, with the concurrence of the finance minister, certain exemptions from payment for operations executed upon private lands, said exemptions consisting in relieving the landholder from contributing toward the expenses for surveys, etc., but he must provide laborers, materials, and cartage.

The direction of all operations executed upon government land belongs to the ministry of agriculture, with its respective departments.

With respect to reclamation work on lands not included in the domain of the Crown, the initiative must come either from the private holders or from the communities interested. When technical

assistance is provided by the Government the entire direction of the work is in the hands of the government engineers. If a loan or subsidy of any kind has been granted by the Government, whether for general land improvement or for a specific purpose, the department retains control over the expenditure. Hydrotechnical operations belong to the department of land improvement and are managed by the chief office of agriculture and land organization.

The most important reclamation works executed by the Government are the draining of the swamps in the west-central and northern provinces, the irrigation of the Mugansk Steppe in the Caucasus, and the irrigation of the Golodny Steppe in Turkestan.

In the Code of Laws, Vol. XII, sections 236 to 320, are contained the regulations as to the rights of riparian owners, the substance of which is as follows:

The right of a riparian owner to the use of waters which flow beyond the boundaries of his property is not exclusively his own, but other riparian owners adjoining enjoy the same right to the use of these waters for the purpose of irrigating their lands.

All waters having their source wholly within the boundaries of one property and which do not, either normally or at certain times of the year, flow beyond the limits of the property, are at the exclusive disposition of the owner of the said property.

The right to the use of water is an appurtenance of the property to which it applies, and can not be ceded or conveyed away from such property. To secure a right to the use of such waters the inspector of irrigation waters issues a certificate to that effect.

In cases of necessity the Government reserves the right to make any needful changes in a canal system for the advantage thereof and economy in the use of water.

Each landholder benefited by irrigation must share in the expenses connected with the maintenance, repair, and management of the system, either by rendering personal labor or by payments of money in proportion to the amount of water applied to his land.

Each landholder must give passage to irrigation through his property, whether as required by adjoining landowners or for the discharge of overflow from lands under irrigation.

Landowners entitled to the use of water enjoy a right of abutment upon the land of opposite riparian owners for the purpose of diverting water, by securing permission to that effect from the Society of Hydraulic Engineers.

The other riparian owner, however, is entitled to a remuneration for granting the privilege.

IRRIGATION IN THE SOUTH OF RUSSIA.

Between the rivers Ural and Dniester and bordering upon the Caucasus and the Caspian Sea there lies a semiarid region, covering approximately 270,000,000 acres and containing a population of 20,000,000 people.

In 1880 an imperial commission was appointed to investigate the physical and climatic conditions of this region with a view to ascertaining the best system of irrigation applicable to the district. The findings of this commission, which was presided over by General Jilinsky, were, briefly, as follows:

The eastern portion of the region consists of a treeless steppe; the soil is sandy and saline, salt marshes abound, and drifting sands are observed. It is devoid of all natural water sources.

Farther north the country becomes rougher and more broken; brush wood appears and in the valleys of the streams copses are found; the soil, which is argillaceous, is mingled with black mold and toward the north salt marshes become frequent.

Toward the west the character of the region changes; the steppes give place to a system of plateaus intersected by river valleys and gorges. The general character of these plateaus is an elevated tableland in the center whence slopes lead in all directions toward the valleys and gorges; and these slopes, scored by ravines and canyons, form the characteristic feature of the country. The predominating soil is black mold; but in the neighborhood of the Black Sea and Sea of Azov the argillaceous sandy soil and the salt marshes appear.

Owing to the physical characteristics of the country above described, and in particular to its timberless condition, it receives but little benefit from the rainfall (which varies from 4.8 inches to 5.5 inches annually); the water passes rapidly over the surface of the land, scouring out the hollows and deepening the gorges; the penetration is very slight and the subsequent evaporation extremely rapid.

The hardly perceptible fall of the rivers—from $5\frac{1}{2}$ to 17 inches in the mile—and the fact that they flow in extremely deep channels, their water level being generally speaking from 150 to 200 feet below that of the surrounding country, rendered all plans for the conservation and utilization of their waters for irrigation purposes according to the ordinary methods quite impracticable, on account of the great expense which such undertakings would necessarily involve. Either the construction of dams to raise the river water to the level of the plain, or the installation of appliances for lifting the water, would involve outlay which the cultivation of the soil, even under the most advantageous conditions, could never justify; and it was decided by the commission that no scheme of impounding river flow could be recommended, and that the only way of reclaiming such portions of the region as were susceptible of reclamation through irrigation was by the retention, through dams and dikes erected in the ravines of the slopes, of the winter rainfall and the melted snow in spring. The commission accordingly recommended the following methods of procedure, according to the needs of the several localities:

(1) The formation of permanent tanks or ponds, whereby the inhabitants and stock of the so-called "alkali" districts might be supplied with wholesome drinking water.

(2) The improvement, by means of artificial flooding, of the "alkali" soil.

(3) Installation of a system of regular periodical irrigation in such localities as were susceptible to that treatment.

In consequence of the recommendations of the commission, and in furtherance of the plans indicated in (1), a number of dams were constructed across ravines in the barren steppes of the peninsula of Tauris, and 9 large tanks were formed there, which in time not merely supplied drinking water to more than 70,000 head of stock, but also aided in great measure the extension of the agriculture of the district.

In carrying out the recommendation of (2) in the report, namely, the reclamation of the "alkali" lands, sites were selected where there was a more or less gradual slope toward a ravine or draw, and a long dike or dam was constructed at right angles to the general slope of the plot, the dimensions being calculated according to the area it was proposed to submerge and the varying levels of the locality. The dam thus formed retained the spring waters upon the surface of the land above it for periods varying from ten to fifteen days and was

then drawn off through sluices into the ravine below the dam. The penetration was ascertained to be four times as great as that caused by the rainfall.

The results of this system were uniformly beneficial. The saline constituents were in part dissolved or carried off in suspension, and in part penetrated so deeply into the soil that the "alkaline" character of the top spit was greatly diminished, so that after successive floodings the former alkali flats became covered with grass and in some places furnished abundant crops of hay.

Where the physical conditions permitted, an extension of this system of flooding, called "irrigation by tiers," was put in practice. By this system, the land it is designed to reclaim is divided into tiers by concentric dikes, and the water from the upper tier is discharged onto the land bounded by the lower dike, and so on, being finally returned to the channel of the stream. The expenses of construction, in the case of the ordinary submersion system, varied between \$3 and \$7 per acre; according to the tier system, between \$3.50 and \$9 per acre.

Six of these irrigation systems were constructed in this region. The most typical of these is the Solenoi Kooba Project, situated in the domain of Valoui, government of Samara, a brief description of which will be found of interest.

The river Solenoi (solenoi=salty) Kooba, an affluent of the Volga, traverses, in the settlement of Valoui, an almost entirely level steppe. In the spring this river receives the snow water from a catchment area of about 450 square miles, and is, during that season, a considerable stream; later in the year it dwindles and finally becomes a succession of pools divided by sand bars. The inclination of the river channel is about 18 inches in the mile. The soil of the flat is argillaceous in character, with slight admixture of humus, alternating with salt marshes and plots impregnated with sulphate of magnesia—a typical "alkali" waste.

After the geological formation had been ascertained by boring, there was constructed across the bed of the Solenoi Kooba an earthen dam, 380 feet long, and 21 feet wide at crest, 30 feet above the bed of the stream. The whole of the outer slope and the upper part of the interior slope of the dam was lined with turf; on the left bank the tail of the dam was returned along the river channel for a distance of 5,300 feet, and then extended in a southeasterly direction for a distance of 12,500 feet across the plain. This dike, varying in height from 3 to 9 feet, and with its crest 2 feet above the flood level of the reservoir, forms the first tier for submersion, and is provided with sluice gates 400 feet in width. The area submerged by this dike is 1,900 acres.

On the same side of the river, at a mean level 3.5 feet lower than the first dike, was constructed a second dike of the same type as the first, but 23,000 feet in length, and provided with two sets of sluices. A third dike, with a still greater length, was constructed below this on the same side, and furnished with sluices for returning the water to the river channel; and on the right bank of the river two other tiers were constructed. The total length of these irrigation dikes amounted to 95,000 feet, and the area commanded by the five tiers was 99,225 acres.

The spring flood waters flowing into the channel of the Solenoi Kooba are stopped by the dam, and overflowing the banks spread over the land above the first row of dikes. The sluices then discharge the water into the second tier, and in like manner to the third, whence the superfluity is returned to the river bed.

When this has taken place there yet remains above the dam and below the level of the banks of the river a body of water $17\frac{1}{2}$ miles long and containing 162,000,000 cubic feet, and this water is used for later irrigation of a periodic character within the lower tiers. After the spring floods had subsided the land selected for regular irrigation was cultivated in the usual manner with very satisfactory results; from 12 to 18 inches of water were supplied, and a good yield of wheat and alfalfa was obtained from the formerly barren "alkali" soil.

It has been estimated that from 10 to 12 per cent of the land in South Russia can be reclaimed and rendered profitable in this manner, and at no very great expense; the cost of a complete system of irrigation, with dam, main canal, and distributaries varying from \$10 to \$30 per acre, while the cultivation of the reclaimed land, notwithstanding the inexperience of the cultivators, produced an average profit of \$7 per acre.

SPAIN.

Reclamation work in Spain may be divided into four classes, as follows:

I. Works constructed and operated entirely by the Government.

II. Works constructed entirely by private individuals without government assistance.

III. Works constructed by private individuals, syndicates, or municipalities, with government aid.

IV. Works constructed by the Government, private individuals, syndicates, or municipalities being contributory thereto.

In class I the only example existing at the present day is the Canal de Aragon y Cataluna, in course of construction.

In class II the only case up to the present is the Canal de Lodosa, projected by the Comision Gestionadora (committee of management) de Lodosa.

Class III. When government aid is desired for a reclamation project, a petition in support of the project must be presented to the governor of the province in which the proposed reclamation work, or the bulk thereof, is to be carried out. This petition must furnish proof of the ownership of the land, of the character thereof (if the purpose is to drain it, of its insalubrity), of the use to which the water is to be applied (if for commercial purposes, a tariff of proposed water rents is required), and a full description of the origin of the water supply. Complete plans of all proposed construction work, of all the area included in or affected by the proposed project, estimate of cost as to the part, if any, included in the public domain, general estimate of cost to the shareholders or associates. The petition must be signed by a majority of the landholders interested, the amount of land held by each being appended to his signature.

With regard to State assistance in reclamation work, the following regulations apply (decree of March 15, 1906):

The State may grant a concession for the employment of public water for purposes of irrigation, provided the amount solicited does not exceed 200 liters per second (about 12.8 cusecs).

If the owners of the irrigable land—a farming syndicate or a municipality which agrees to furnish water without charge to irrigators—desire a concession for more than 200 liters per second, the State may aid in the construction of the requisite reservoirs and canals, and this aid will consist in a payment (based upon the estimated cost of the project) for each second-liter of water drawn off, of one-half of the entire cost per liter, but not more than 350 pesetas (\$67.55) in all. In the case of a commercial enterprise, the State contribution is limited to 40 per cent of the total cost per liter, and may not exceed 200 pesetas (\$38.60). The concession will be granted by the ministry of public works, upon receiving the report of the government engineers in charge of agricultural improvements, and will be paid upon presentation of the certificate of the chief of the public works of the province in which the lands to be irrigated are situated, and this certificate must show the number of liters used, the number of hectares (2.47 acres) irrigated, and that the licensees have complied with the conditions of the concession. These certificates shall be rendered annually for a period not exceeding six years from the completion of the works, and after this period is completed all claim to government assistance shall lapse.

The amount estimated to be sufficient for these subsidies shall be included in the general budget, and if this sum proves insufficient to meet all claims the persons whose subventions are unpaid shall have no right of redress against the Government, nor shall interest be paid on account of the delay; but in the succeeding year preference shall be given to those enterprises that received no subsidy in the previous year.

Class IV. Under this head come the Trabajos Hidráulicos, or hydraulic works, which are by far the most important of the operations in connection with land reclamation in Spain at the present day. The system according to which these are constructed and operated is in general as follows:

An association of persons interested (*sindicato de riegos*) is formed and enters into a contract with the Government on the following terms:

The Government undertakes to construct and install a complete irrigation system consisting of reservoir, canals, buildings, and all appurtenances for the syndicate. The construction shall be under the supervision and control of a committee of five, three of whom shall be elected by the association, one appointed by the minister of agriculture on the nomination of the chief engineer of the division, and the fifth shall be the engineer in charge of the works, appointed directly by the minister of agriculture.

The contribution made by the association toward the cost of the irrigation system varies according to the circumstances of the case, but usually consists in the payment of one-half of the cost of the works, this contribution being made partly during the construction of the system and partly by a series of annual payments, not exceeding 25, after the plant is in operation, interest at the rate of $1\frac{1}{2}$ per cent per annum being charged on these latter payments. As soon as

these payments are completed, the irrigation system becomes the exclusive property of the association.

As soon as the construction work is completed the association is charged with the operation and maintenance of the irrigation system, subject to the conditions of the contract with the Government.

Each of these important undertakings must be authorized by a special decree, which sets forth the terms of the contract, the amount of the public contribution, the terms of payment, etc.

During the last four years (1903 to 1906) eight important reclamation works, at an estimated expense of over \$2,000,000 (11,000,000 pesetas), have been undertaken. Particulars as to the area irrigated, duty of water, and probable cost of construction per acre are not yet available. The most important of these hydraulic works are: The canal of Santa Maria de Belsue (1,800,000 pesetas), the Azuebar Reservoir (2,587,000 pesetas), the Cueva Foradada Reservoir (1,780,000 pesetas), the Canal de la Pena (1,550,000 pesetas).

Following is a translation of the royal decree authorizing the construction of the La Pena project:

I. The minister of agriculture, industry, commerce, and public works is authorized to carry out within the term of five years the irrigation works of the reservoir of La Pena for the sums of 762,030.75 pesetas for construction and 792,511.98 pesetas for administration, according to his estimate, the same including 2 per cent additional for unforeseen expenses and another 2 per cent for accidents.

II. He is hereby similarly authorized to carry out within the same term the antecedent projects for the deviation of the public highway from Saragossa to France by way of Canfranc, and of the railway from Huesca to France by way of Canfranc, which are included in the reservoir project.

III. Without prejudice to the foregoing there shall be acquired, either by auction or by tender, the principal material to be used in the construction of the reservoir, such as lime, cement, metal work of all kinds, and, except in the case of just exceptions, stone and sand; on the other hand the system of public bidding for the contract for the superstructure of the alteration of the railroad may be departed from.

IV. The preceding authorization is understood to depend upon the acceptance of the conditions of the present decree by the executive committee of the La Pena Reservoir.

V. In conformity with the required formalities a syndicate of irrigation of the La Pena Reservoir shall be constituted, in which the communities contributing to the construction of the reservoir shall be represented, and which shall be governed by a regulation or ordinance such as is provided in the tenth section of this decree, the syndicate being permitted to add to its number upon the inclusion of fresh territory, if it be deemed convenient.

VI. The syndicate of the reservoir shall make the following contributions to the works:

(a) A cash contribution of 700,000 pesetas (\$135,000), payable at certain periods in proportion to the work executed.

(b) The surrender of the original project at the expense of the syndicate.

(c) The contribution during the period of construction of a continuous current of 120 horsepower, furnished by the Teledynamic Company of Gallego.

(d) An annual payment, which shall commence to be made five years after the completion of the reservoir, and may be progressive, whereby shall be effected within the maximum term of twenty-five years the amortization of the difference between the 50 per cent of the estimated cost of the works (or of their real cost, should that prove less than the estimate) and the sum of the values of the contributions (a), (b), and (c); the value of the last two to be determined by agreement between the delegate of the executive committee and the chief engineer of the division of public works of the Elbro; the council of public works to act as a third party in case of disagreement.

VII. Pending the complete amortization aforesaid, the syndicate shall pay interest at the rate of $1\frac{1}{2}$ per cent per annum upon the sum remaining unpaid.

VIII. When the 50 per cent has been completely amortized in the prescribed manner, the reservoir shall become the exclusive property of the syndicate.

IX. For the construction of the reservoir and of the works connected therewith or complementary thereto, there shall be formed a construction committee composed of five members, three of whom shall be elected at a general election by the syndicate; one shall be nominated by the minister of agriculture, industry, commerce, and public works on the recommendation of the chief engineer of the division of hydraulic works of the Ebro, the fifth being the civil engineer of highways, canals, and harbors directing the construction (director of the works), whom the minister shall appoint without the intervention of the committee.

X. When the construction is completed, the operation and maintenance of the works shall be vested in the syndicate by means of the administrative regulations cited in Article V, the same having to be approved by the minister of agriculture, industry, commerce, and public works.

In drawing up the regulations, the following rules must be adhered to:

(a) The syndicate shall be obliged to deliver from the reservoir a quantity of water equal to the quantity entering it, except when this latter shall be in excess of the amount to which the inferior water-right owners are entitled, including the amount of the concession granted to the Sociedad Teledinamica del Gallego.

(b) The ownership of the reservoir carries with it the exclusive right to all the water which, at any point in the canal, is in excess of the volume of water which would run there independently of the reservoir.

(c) The tariffs which shall be decided upon must not exceed those proposed by the executive committee, equal to those in force on the Imperial Canal.

(d) For any new distributaries that may be established the basic principle, according to which the water shall remain inalienable from the land, shall be departed from, and tariffs shall be drawn up fixing the amount payable per hectarea (2.47 acres), irrigated, and the minimum of water which must be supplied in order to make payment in full obligatory upon the irrigators.

(e) A preferential right to the water in the reservoir shall be established in favor of those corporations or individuals that have contributed toward the realization of the project.

XI. The operation and management of the reservoir works shall be subject to the inspection of the Government, represented by the chief engineer of the Ebro division of the hydraulic works.

XII. If the works shall be abandoned by the syndicate and their efficiency and maintenance thereby endangered, so that they can not perform the service for which they were intended, the Government shall take possession of the same and may either operate them in person or transfer the operation to a third party, after proceedings, in which the council of public works shall be heard, have been taken.

XIII. The committee of construction of the reservoir shall without loss of time make full detail plans for the deviations of the highway and of the railway, and forward them, along with the respective estimates, to the Ebro division of hydraulic works, so that the latter, after receiving the reports from the offices of the Huesca division of public works and the second division of railways (which in its turn must give a hearing to the grantee company operating the railroad), may submit the whole proceedings, together with its report, to the general division of public works for final decision.

SWITZERLAND.

Irrigation is but little practised in Switzerland, the natural water supply being in general sufficient. There are no important irrigation systems. In some of the upper valleys the water from the glaciers is used for flooding the meadows during the summer drought, and in the Canton of Valais these glacier-fed streams are conveyed to the valley of the Rhone in canals (locally called "bisses"), which are constructed either by municipalities or associations of landholders. The Federal Government makes appropriations toward the cost of construction—usually about 40 per cent—and the control and maintenance of the "bisses" are vested in the association or municipality interested. These pay a nominal sum to meet the

expenses of upkeep, etc., for the water supplied to them, while outsiders are charged according to the amount of water they use.

With regard to land reclamation in general, the Federal Government assists all enterprises of this character very liberally on the following terms (law of 1893):

Applications for federal subvention in aid of land reclamation must be laid before the federal council by the government of the Canton interested, and must be accompanied by full information as to the character of the soil, the cost and importance of the project, and all requisite technical particulars relating thereto.

The association of water users, the municipality, or Canton interested must, severally or together, furnish at least as large a proportion of the estimated expense as the Federal Government, whose share shall not, in general, exceed 40 per cent of the total cost, but in special cases a federal grant not exceeding 50 per cent of the total expenditure may be made in aid of satisfactorily constructed works of approved utility, which have been unsubsidized, or only partially subsidized, by the cantonal government.

The federal subsidy is as a rule payable after completion of the works and inspection thereof by the federal engineers, and the cantonal government is charged with the maintenance of the same, being at liberty to divide such expenses between the municipalities, associations, or individuals interested.

The Federal Government may also undertake to pay a share—usually one-half—of the expenses of preliminary examinations, surveys, estimates, etc., and for the employment of skilled engineers for the superintendence of construction work, when the project is one of public utility and unusual importance.

The only important land reclamation project in Switzerland at the present day is the draining of the marshes of the Orbe, a river emptying, along with several other streams of less importance, into a depression about 10 miles long and 4 miles wide, lying in the northern part of the Canton of Vaud, at the foot of the Jura Range, southwest of the Lake of Neuchatel, with which it was undoubtedly united during the glacial era. For more than a hundred years various attempts have been made to drain this, the only insalubrious district in the Republic, but no serious undertaking was instituted until the year 1854, when a company of contractors for "the draining of the marshes of the Orbe" was formed under the authority of the Canton of Vaud. The plan adopted by this company consisted in the construction of two sets of canals, one to drain the marshes themselves, the other to confine the river Orbe within a corrected channel. After eight years of more or less intermittent work the enterprise was abandoned for fourteen years, when the formation of the "disciplinary colony of Orbe," a sort of cantonal reform farm for inveterate drunkards and bad characters, furnished the canton with the necessary workmen. The solution of the real difficulty—the removal of the standing water—however, was not discovered until the plan for building a canal from the Lake of Bienne to the River Aar, thereby lowering the level of the lakes of Neuchatel, Bienne, and Morat and providing an outlet for the hitherto stagnant waters of the Orbe, was adopted. The construction in connection with this last project was begun in 1896 and is expected to be completed in 1915; the total estimated cost of the work, including interest on the deferred pay-

ments, is \$175,720 (the expense of the construction previous to 1896 was \$300,672). Of this amount the Federal Government pays a proportion varying in different districts from $33\frac{1}{3}$ to 40 per cent, according to the classification adopted; the remainder is divided between the communes—where it takes the form of an addition to the yearly tax rate—and the proprietors interested, the proportion of the latter averaging about three times as much as that of the communes. An accurate and detailed classification of the lands affected by the proposed reclamation was made and the share leviable upon each estimated according to the cost of the work done within the boundary of the area under consideration, and the benefit estimated as accruing therefrom. The project will reclaim about 20,000 acres in the Canton of Vaud.

ALGERIA.

The physical conformation of Algeria presents, broadly speaking, three distinct strips of territory, running parallel to the Mediterranean and dividing the country into three districts, differing considerably from one another both physically and climatically. The most northerly of these zones of territory, which embraces the region lying between the peaks of the Atlas Range and the seacoast, is called the "Tell." South of the peaks of the Atlas lies a high table-land known as the Grands Plateaux; and still farther south the slopes of the table-land, together with the sandy stretches beyond, constitute the district of the Sahara. As the conditions affecting irrigation are to a large extent governed by the climatic conditions of these districts, any study thereof will properly follow the lines of physical demarcation.

IRRIGATION IN THE TELL.

The Tell is unquestionably the most fertile region of Algeria. The great plains that lie between the foothills and the coast are dotted over with prosperous farms and orchards—cultivated for the most part by European settlers. In the valleys to the south, where the alluvial deposit is deep and rich, and also on the gentle slopes of the foothills, agriculture of every sort is practised. It will surprise those unacquainted with this part of Africa to learn that the average rainfall in the Tell is about the same as in France, varying from 20 inches in the extreme west to more than 40 inches in Kabylia, but the high temperature and consequent rapid evaporation prevailing throughout the greater portion of the year, combined with the unseasonable—from the standpoint of the agriculturist—periods of the rainfall, render artificial aid a requisite for successful agricultural operations. The dry season extends from June to October, while the rainy months are December and March. The alternations of the rainfall is in groups of years, three, four, or more years of one character being followed by several years of the opposite, a regular alternation of wet and dry years being unknown.

In a pamphlet published in 1900 by the French reclamation service (bureau de l'hydraulique agricole) the number of irrigation enterprises in Algeria in which the Government has been concerned in one way or another is given as 576, and the area served by them as about half a million acres. Three hundred and ninety-five of these irrigation systems, including all the important government works

of modern times, are in the Tell; 129 are in the Grands Plateaux, and 52 in the Sahara. Most of these irrigation systems are extremely small, constructed after the most primitive methods long before the advent of the French, and managed by groups or associations of interested landowners, and the intervention of the state has in the large majority of cases been confined to the settlement of disputes, the suggestion of improvements, and furnishing technical assistance to those requesting it. In the Tell, however, where the European settlements are numerous, the Government has constructed a number of irrigation systems, including seven of considerable importance. Of two of these, the Cheurfas Dam and the Habra Dam, an account will be given later. With regard to these constructions, the experience of the bureau de l'hydraulique agricole seems to be that owing to the soft and friable character of the bed rock, which is ill adapted as a foundation for large masonry dams, and the consequent losses and expense from fissures, breaks, and washouts, the construction of large masonry dams is unadvisable and that a succession of small weirs and low dams, cheaply and easily constructed, will be more in conformity with the character of the strata and render equally efficient service.

During the earlier years of the French occupation no rules existed as to the manner in or extent to which the Government might aid in the irrigation enterprises of the country. Sometimes a subsidy, usually a generous one, was granted to a commune or association; more frequently the Government constructed the system and then handed it over as a free gift to the parties interested on the understanding that they should keep it in proper repair. This system, or rather lack of system, was found to work very badly, and since 1889 the Government subsidizes communes and associations of water users only upon their undertaking to pay a part of the cost of the enterprise and to operate and maintain the system in a satisfactory manner after construction. The government contribution, which is non-repayable, is rarely less than two-thirds of the total cost, generally three-fourths, and sometimes even more. Of this contribution, about one-fifth is charged to the ministry of the colonies (but not after 1900), and the remainder forms part of the budget of the hydraulique agricole. The public contribution is usually divided between the commune and association interested, the rate of assessment being regulated according to the circumstances of each case, but the bulk of the payment invariably falls on the association, the communal share being rarely more than one-fifth that of the association, and frequently much less. Thus, in the years 1889 to 1898, a total sum of \$1,450,000 was expended upon irrigation enterprises in Algeria. This was (approximately) apportioned as follows:

Hydraulique agricole	\$960, 000
Colonies	195, 000
Department of Algeria	5, 000
Communes	23, 000
Associations	272, 000

In addition, the Government expended in Algeria during these ten years the sum of \$1,547,000 on reservoirs and canals for supplying towns and villages with water; so that the total expenditure for storage and distribution of water was nearly \$3,000,000, to which the associations of water users contributed \$276,000.

DUTY OF WATER.

In the irrigation districts of the Tell, constructed by the Government and cultivated by European settlers, the average duty of water has been established as follows:

	Acres per cusec.
Cereals and vines.....	420
Meadows.....	280 to 350
Communes.....	23,000
Market gardens.....	70 to 100

These figures vary considerably according to the porosity and composition—whether clayey or sandy in character—of the soil. In proportion to the distance from the point of delivery an allowance for loss has been established differing for each district, the coefficient for the valley of the Hamma being $S(1 + \frac{D}{10,000})$, where S =superficies and D =distance in meters. For the duty of water in the same district the coefficients are: Gardens, 90; orchards, 30; meadows, 20; vines and cereals, 16.

THE CHEURFAS BARRAGE.

Upon the site of a small diversion dam, constructed in 1844, a wall 53½ feet high was built in 1849, creating a storage capacity of 106,000,000 cubic feet. This quantity proving insufficient and out of proportion to the flow of the River Sig, a second masonry dam, 96 feet in height, was built across a gorge higher up the river. The construction, which was executed in 1880–1882, cost \$230,000, of which the State contributed \$60,000 and the syndicate of water users paid the rest.

On the 8th of February, 1885, the water forced its way between the end of the dam on the right bank and the side of the mountain and made a breach 135 feet wide on the right bank of the river, emptying the reservoir with great rapidity. The small dam downstream was entirely swept away.

The syndicate immediately built a masonry diversion dam on the site of the small dam, to serve the same purpose as the original weir of 1844. They then undertook to replace the upper reservoir. The masonry dam, which was undamaged, was extended across the break in the right bank to solid rock. This work occupied seven years, from 1886 to 1892, and cost \$360,000, to which the Government contributed \$275,000.

The length of the crown of the dam, which before the accident was 355 feet, was extended to 708 feet. The dam consists of two walls of masonry, 407 and 301 feet, respectively, forming an angle of 128°. The construction of the dam walls is as follows:

Upon a rubble foundation, 33 feet deep, 138 feet wide at the base, and 79 feet wide at the level of the river bed, was built a masonry wall 72 feet wide (inset 3½ feet on either side), 98 feet high. The width at top is 4 meters (13.12 feet). A perpendicular from the bisection of the crown to the top of the foundation shows a reduction in width on the upper side of 3 in 5 and on the lower side of 15 in 17. The spillway, 3.28 feet lower than the top of the dam, is 197 feet wide.

The capacity of the Cheurfas reservoir is 636,000,000 cubic feet, and it serves 17,000 acres.

THE HABRA BARRAGE.

The Habra dam was originally constructed in 1865-1873 by the Franco-Algerian Company on the Habra River, about 7 miles above Perregaud, at an expense of \$480,000. The dam gave way on December 15, 1881, and the expense of replacing it amounted to \$276,000. This sum was paid by the Government, but the company was afterwards required to pay a contribution of \$90,000. In addition the water users contributed \$8,800 for the installation of hydraulic sluice gates.

The total length of the crown of the dam is 1,505 feet, which includes a spillway 410 feet wide at a height of 105 feet above the bed of the river and 1,095 feet for the dam itself, which is composed of two walls of masonry, 685 feet and 410 feet, respectively, forming an angle of 176.30° on the downstream side.

The storage capacity of the Habra dam was originally 1,060,000,000 cubic feet, but silt deposits have reduced this to 850,000,000. It serves about 90,000 acres with water for irrigation and also furnishes the water supply for the town of Perregaud.

It is noteworthy that out of the 7 principal irrigation systems described in the pamphlet of the bureau, 3 have given way, necessitating extensive repairs and in some cases complete rebuilding, and 2 have proved failures owing to the deposits of silt, the capacity of the Barrage de la Djidiouia, for instance, being reduced in fourteen years from 2,450,000 cubic feet to 420,000 cubic feet, or about one-sixth of its former volume. The systems which have proved most satisfactory are the small reservoirs, serving from two to five thousand acres.

IRRIGATION IN THE GRANDS PLATEAUX.

Only 1 of the 129 systems enumerated by the hydraulic bureau is of government construction. The rest represent the unaided efforts of the inhabitants, dating from a period long anterior to the French conquest, to turn the mountain streams to profitable use. The verdict of the bureau with regard to this district is that it is, from the point of view of the irrigation engineer, the best handled in Algeria. The systems themselves, which are very small, are managed without trouble or disputes. A long experience has taught the inhabitants the construction best adapted to the conditions of the locality, and the duty of water is much higher on the Grands Plateaux than in any other part of Algeria, reaching in many districts as high as 700 acres for cereals and vines, and other products in proportion.

The government work referred to is a diversion weir at Oued Chair, consisting of a masonry dam 22 feet high and 670 feet long, by which the waters of the Chair are turned into a canal which supplies about 2,000 acres of cereal crops, with an average flow of 7 cusecs.

IRRIGATION IN THE SAHARA.

The valleys that descend along the southern slopes of the Hauts Plateaux into the sandy plains of the Sahara have been for many years, probably for centuries, the scene of intense cultivation; every

stream is utilized to its utmost capacity, and the oases to the south owe their existence to the canals that conduct the water from the foothills across the desert.

The water supply of the valleys and foothills of the Sahara being thus carefully conserved and distributed, the Government has done no construction work in connection with irrigation in this district; it has, however, occasionally assisted the inhabitants to secure a more efficient service of water. Thus in 1899 the State shared with the commune of Biskra the expense of cementing the canals supplying water to the oasis of Oumache, in consequence of which operation the supply was more than doubled, the insalubrious marshes, the result of infiltration of long standing, entirely dried out, and the prosperity and population of the whole district very largely increased. Since then other operations similar in character have been carried out in the Sahara with equal success.

Farther south, in what may be called the Sahara proper, the Government has been more active; many artesian wells have been drilled, old and choked-up wells have been cleaned out, deepened and repaired. In these operations the intention of the Government has been to require the inhabitants to bear a part of the expense wherever possible, as it is found that this gives them a sense of responsibility for and interest in the enterprise otherwise lacking, and that they take in consequence more pains to keep the canals and wells in proper repair. The proportion required of them is small, consisting merely, in many cases, in their paying for the casings left in the wells after they are brought in.

THE DRAINING OF THE MARSHES.

Recognizing the hygienic importance of drainage in a country like Algeria, the Government has carried out a number of operations of this character in different parts of the Tell, either as a state project or with the cooperation of the communes and departments; in some cases the proprietors benefiting by the undertaking have borne a share of the expense.

The direction de l'hydraulique agricole enumerates 23 of the principal drainage undertakings, of which the following may be cited as examples:

The unwatering of the Valley of the Gardens at Mostaganem, which cost about \$26,000, of which the Government contributed \$16,400, the department \$2,000, and a syndicate representing the local landholders and the three communes interested \$7,600. The results have been entirely satisfactory; a large quantity of land has been restored to profitable culture, and the malaria formerly prevalent in the district has completely disappeared.

The Lake Halloula, a depression in the western end of the Mitidja, just behind the range of low hills known as the Sahel of Algiers, was in winter a sheet of water of about 5,000 acres in extent, and in summer a fever-breeding swamp. The draining of this swamp was begun some fifty years ago by the army engineer corps, and the flooded surface was in consequence reduced to little over 500 acres. A sum of \$4,000 is annually appropriated for the purpose of maintaining the existing canals and extending the system. The surface inundated does not, even in rainy winters, exceed 300 acres, and will

probably eventually disappear entirely. The expense of this work was borne by the Government. The State has been urged to expedite the draining of this region by constructing a tunnel through the mountain, at a cost of \$280,000; but it was decided that the result attainable did not justify the outlay.

The unwatering of the plain of the Mitidja immediately south of Algiers, has been effected by means of a network of canals, which empty into the numerous rivers that traverse the plain. This district, which was formerly a pestilential swamp, known as "the grave of Europeans," is now one of the richest and best cultivated in the colony. The work was executed by a syndicate, which maintains the canal system, about 45 miles, in working order.

Although the Government has done a great deal in this direction, it recognizes that much more yet awaits accomplishment. Several important drainage projects have been approved and will doubtless be carried into execution. The greatest of these undertakings is the contemplated unwatering of the lake of Djendli which, when carried into effect, will render fertile and open to colonization an immense region now uninhabitable and pestilential.

PROTECTION AGAINST FLOODS.

This branch of reclamation work has received hitherto but little attention in Algiers, but the Government considers that it is destined to be greatly developed in the future, and numerous associations are being formed with this object. The policy of the Government with respect to work of this character has been to leave the execution of the work to the riparian proprietors, as being the only persons directly interested, except where a public highway is in danger from freshets. Monetary assistance, however, has been granted as in the case of irrigation enterprises.

The most important work of this character is the embanking of the Oued Djemaa, which is effected by means of solid masonry dikes. Toward the repairs of the dike on the right bank of the river the Government contributed \$6,600, and also four-fifths of the expense of the dike on the left bank, the estimated cost of which was \$19,000. In this case the amount of the government subsidy was determined by the consideration of the protection to which the settlers in the plain below the Djemaa were entitled.

CAPE COLONY.

Government participation in land reclamation by means of irrigation is, in the Cape of Good Hope Colony, intrusted to the irrigation department, consisting of a director of irrigation and headquarters staff, three district engineers with field assistants, and two survey parties.

For administrative purposes the irrigable portion of the colony—which, practically speaking, amounts to the whole area, with the exception of the eastern corner, between Natal and Basutoland—has been divided into three circles, of which the district engineers are in charge; and for judicial purposes into sixty-five water-court districts, corresponding wherever feasible to the county divisions of the colony.

The legal basis of irrigation development in the colony is the act of 1906. This act is in part a consolidation of past legislation and in part marks an advance in respect of promotion of irrigation development by the State with surveys, professional advice, loans on easy terms, and the like.

Under the terms of the act the irrigation department carries out systematic reconnaissance surveys, having for their object the discovery of the irrigation possibilities of the country, large and small, chiefly the latter; the collection of hydrographic data and the general education of the farming community in irrigation matters; and professional engineering advice is given at nominal rates by the department engineers to parties consulting them.

The main principle of the present irrigation policy in the colony is to foster to the utmost extent the development of irrigation by individuals or cooperative bodies. The construction of purely state irrigation schemes, though a few small ones exist, is considered for a variety of reasons at present inexpedient.

The following are the more important provisions of the irrigation act of 1906:

PART I. DEFINITIONS.

Perennial stream.—This term means a natural stream which in ordinary seasons flows for the greater part of the year in a known and defined channel and the water of which is capable of being applied to the common use of the riparian proprietors. Provided that a stream which in part only of its course satisfies these conditions shall be deemed to be a perennial stream in so far only as regards such part.

Intermittent stream.—This term means a stream which is not a perennial stream, and into which the natural surface drainage waters flow from the lands of more than one riparian property. Provided that a stream shall not be deemed to be an intermittent stream above the highest point of its course at which the natural surface drainage waters from the lands of more than one riparian property unite, or for such lower portions of its course as satisfy the conditions of a perennial stream.

PART II. UTILIZATION OF STREAMS.

1. Every person is entitled to the exclusive and unlimited use and enjoyment of all water rising on his own land: *Provided* that nothing in this section shall affect the right of a riparian owner to a reasonable share of water which, rising on the land of an upper proprietor, flows down for the greater part of the year beyond such land in a known and defined channel and has for a period of at least thirty years been used by such riparian owner, or shall affect another existing right.

2. Every riparian owner is, subject to all existing rights of other persons and to the provisions of this act, entitled to a reasonable use for purposes of irrigation of the water of a perennial stream with reference to which his property is riparian.

3. Subject to the existing rights of others, every riparian proprietor is entitled to use the water of an intermittent stream flowing on, to, or over his property, by diverting it on to his riparian land for the irrigation thereof; and he shall moreover be entitled to impound and store such water for the said purpose and for domestic, agricultural, manufacturing, and drinking purposes: *Provided, however,* That if at any time any riparian proprietor along a stream shall consider that an upper riparian proprietor is impounding or storing a greater quantity of the water of such stream than he could reasonably be expected to use for the purposes stated, it shall be competent for the first-mentioned proprietor to apply to the water court for an order declaring the quantity of water which, in the opinion of such court, such upper proprietor requires to impound or store for the said purposes; and thereafter such upper proprietor shall not be entitled to impound or store any greater quantity of water than that authorized by such order.

4. Where, owing to variation in its course from natural causes, a stream which constitutes the boundary of two or more properties riparian thereto ceases to flow between or separate such properties, the boundaries of the respective properties shall remain as theretofore, but the changes in the course of the stream shall not deprive the owner of the property so cut off from the stream of his riparian rights, and every such last-mentioned owner shall be entitled to apply to the water court of the district in which his property is situate, at any time within ten years from the date of such change in the course of the stream to prescribe such point or points on the new course of such stream as to the said court may appear necessary, with right of access thereto along a convenient line to be determined by such court, to enable such owner to take water from such stream for domestic purposes and to water his stock.

5. Accretions formed by any stream which add gradually and imperceptibly to a riparian property belong to the riparian proprietor of the bank to which such accretions are added, and the provisions of the preceding section shall not apply where the stream changes its course but still continues to flow in the same bed, although in a different channel. In such a case, the land in the river left vacant by the change shall belong to the owner of the bank adjacent to the ground so left vacant.

6. When a diversion, as specified in section 4, takes place from natural causes to the detriment of an owner riparian to any stream, it shall be lawful for the owner thus prejudiced to apply within one year after the said diversion has taken place to the water court of the district for permission to construct such works as in the opinion of the water court may be necessary for the restoration of the stream to its old channel, and within such period of time as the water court may decide and shall prescribe.

PART III. RIVER DISTRICTS AND BOARDS.

7. Any three or more riparian owners who, being entitled to use the water of a stream or streams, deem it expedient that there should be a combined system of control over such stream or streams, may present a petition to the minister to whom the administration of this act is assigned, praying that an area containing the stream or streams, together with the properties riparian thereto, may be constituted a river district: *Provided*, That the persons signing the petition be owners of not less than one-tenth part in area of the riparian land irrigated from, or of the properties riparian to, the stream or streams within the limits of the proposed district.

8. The minister shall thereupon cause an engineer to make such inquiry into the subject-matter of the petition as the minister shall deem necessary. Due notice of the inquiry shall be published in the Gazette and in some newspaper circulating within the proposed district, and in such other manner as the minister shall direct, and the engineer shall report the result of his inquiries to the minister, who may, if he thinks fit, vary the limits of the proposed district. The minister shall then satisfy himself that the owners of more than two-thirds of the properties riparian to the streams within the proposed district, or the owners of more than two-thirds of the riparian lands irrigated from the streams within such properties are in favor of the creation of the district, such owners in each case to represent more than two-thirds of the total number of owners; and in either event the governor may proclaim the area to be a river district: *Provided*, That no tributary stream shall be included in a river district containing the stream of which it is a tributary, unless the owners of more than two-thirds of the total area of the properties riparian to the tributary stream, within the limits of the proposed district, or of more than two-thirds of the riparian lands irrigated from it within these limits, are in favor of the inclusion, such owners in each case to represent more than two-thirds of the total number of the owners.

9. The superintendence of all acts relating to the conservancy of the streams in a river district, and to the storage, diversion, and use of the water therein shall, subject to existing legal rights and the provisions of this act, be vested in a board to be called a river board. The board shall be a body corporate and shall have such name as may be given to it by a proclamation of the governor, and by that name it shall sue and be sued, hold property and have perpetual succession.

10. The river board shall consist of not less than 3 nor more than 11 members, elected by the riparian owners and rate payers within the district. The qualification and scale of voting being as follows:

(1) Where the ratable values of a river district have been determined every owner of not less than 1 morgen (2.11 acres) of ratable property or more than 5 morgen shall have one vote in respect of each vacancy to be filled up at the election, and one for every additional 5 morgen or part thereof up to 50 morgen (105 acres) and thereafter an additional vote for every 25 morgen in respect of each vacancy.

(2) Where the ratable values of a river district have not been determined every owner of property riparian to a stream in the district may vote at an election of members of the board, the scale being as follows: If the valuation of the property in respect of which he is entitled to vote does not exceed £500 (\$2,425) he shall have one vote in respect of each vacancy required to be filled by the election and an additional vote for every additional £500 or part thereof.

11. The duties and powers of the board shall, subject to the provisions of this act, include the following:

(a) To exercise general supervision over the streams in the district and where necessary to cleanse, deepen, widen, straighten, or otherwise improve them; to protect the sources of their water supply and prevent waste and any unlawful act which might diminish that supply; by lawful process to prevent or stop any unlawful diversion or storage of the water and to remove any obstruction in the course of a stream: *Provided*, That the board shall have no right to institute or defend any action involving a declaration of rights without the consent of two-thirds of the riparian owners within the district present at a meeting specially called for that purpose.

(b) To investigate and record, in accordance with regulations the quantity or share of water which, at different stages of flow in every stream in the district, every person having any rights in respect of the water in the stream is entitled to use, and the times at which such quantity or share may be taken, where these have already been legally fixed and defined.

(c) To supervise the distribution and use of water from the streams in the district in accordance with established rights.

12. Any person aggrieved by an order or act of the board may make application for relief to a water court or other competent court.

13. A river board may, with the consent of the rate payers given at a meeting specially called for the purpose, levy rates for defraying all expenses incurred or to be incurred by the board.

PART IV. IRRIGATION DISTRICTS AND BOARDS.

14. Irrigation districts and boards are created and appointed in a manner similar to that prescribed in the preceding sections for the creation and appointment of river districts and river boards; and an irrigation voters' list must be prepared and annually revised and a copy kept at the secretary's office for inspection by any person concerned.

15. The duties of an irrigation board include the performance and superintendence of all acts relating to the purchase, construction and maintenance of such reservoirs, channels, or other works of irrigation or drainage as are necessary for the proper irrigation of the irrigable areas and the drainage of the respective properties in the district, and of all matters relative to the administration, control and use of the works and the water stored or diverted thereby. It shall be the duty of the board to purchase or construct, and to maintain the works necessary for such irrigation or drainage; to obtain or conserve the supply of water required therefor; and to arrange for the equitable distribution of the water stored or diverted by the board's irrigation works.

16. An irrigation board shall consist of not less than 3 nor more than 7 members.

17. A member of an irrigation board shall not receive any salary, allowance, fee, or reward for or on account of his office as member; nor shall he enter into a contract with the board for an amount exceeding £10 (\$48.50) or be directly or indirectly interested in any such contract, unless he has received special permission to do so given at a meeting of the voters of the district.

18. An irrigation board may levy rates, to be called "irrigation rates," for defraying all expenses incurred or to be incurred by the board; and such rates shall be levied upon and in respect of every property having an irrigable area in the district and shall be payable by the owner of the property. The rates shall be assessed annually by the board at a uniform sum per morgen (2.11 acres) of irrigable area.

19. The irrigation rates shall be due and payable at the office of the board on a day to be appointed by the board, and if, within one month from the day appointed the rates have not been paid, the board may, without further demand, sue for and recover them as a debt by action in the court of the district, or other competent tribunal; and may, by such means as the board thinks fit, stop water flowing from any irrigation work of the board into the lands or premises of which the rates are in arrear. The foregoing applies also to the rates levied by river boards.

PART V. WATER COURTS.

20. A water court shall consist of a resident magistrate having jurisdiction over the whole or some portion of the water district, who shall sit with two assessors selected from a list of water-court assessors, not less than 10 nor more than 25 in number, appointed by the governor after consultation with the divisional council. The names of the assessors selected shall be notified to all the parties in the contemplated proceedings, any one of whom may lodge an objection to any one or more of those selected: *Provided always*, That an assessor shall not sit or take part in proceedings in the result of which he has any direct or indirect personal interest.

21. The general powers and duties of a water court shall be as follows:

(a) On the application by any person as to a matter in dispute regarding the use, diversion, or appropriation of water within the district, or as to any matter which by this act can be brought by such person before such court, to investigate the matter and make order thereon.

(b) On the application of any interested person, to investigate, define, and record the rights to the use of the water of any stream, channel, reservoir, or source of supply, and to apportion the water for irrigation or other purposes, where such rights have not been defined or such apportionment made by a competent court or in other legal manner.

(c) At the request of the minister or any superior court, to report to such minister or court on the use or waste of water diverted from any stream, or on any matter arising out of the provisions of this act.

(d) To grant, in accordance with regulations, permits for the use of the water of any intermittent stream in the district.

(e) On the application of an owner of land riparian to a stream, to determine and fix in accordance with regulations the place or places, either upon the said land or upon any land higher up in the course of the stream, at which such owner shall be deemed to have a right to the use of the water, and to determine, if required, the nature and extent of such use at such place or places, having due regard to the rights of other owners.

(f) On an application from any person for the removal of or interference with any dam, weir, or other obstruction in the course of a stream, to investigate the application and make order thereon, including, if the application is granted, the compensation, if any, to be paid to any person affected by the order.

(g) Generally, to do any matter or thing in this act provided to be done by such court.

(h) On the application of any interested person, to investigate, decide, and record, in the case of any stream whose character has not already been defined by a competent court, whether such stream is perennial or intermittent: *Provided*, That an appeal, to be prosecuted within three months, shall be from any such decision of a water court to a superior court at the instance of an interested person.

22. Any person aggrieved by the order of a water court may appeal to the supreme court to set it aside or vary it; but no appeal shall be entertained unless it be made within three months after the making of the order, nor unless notice be given as provided by regulations.

PART VI. EXPROPRIATION OF LAND AND ACQUISITION OF SERVITUDE.

23. If at any time the Government shall require or deem it to be expedient to take or use any land, or the bed of any river, stream, or river tributary, for the purpose of irrigating any land or constructing thereon any dam, reservoir, or other irrigation work, and there may not be any right or power by law to take or use such land or property without the consent of the owner thereof, it shall be lawful for the governor to take or use such land or property for the pur-

poses aforesaid, and the proprietor thereof shall thereupon be entitled to compensation, to be settled in case of difference by arbitration.

24. It shall be lawful for any river or irrigation board, or their officers or servants, from time to time, to enter upon and take possession of such lands and premises within their district, covered or uncovered with water, as may be necessary to enable them to carry out the purposes of this act; to purchase any such lands or premises; and to dig, get, and carry away out of or from any such lands any materials which may be necessary to enable them to carry out the said purposes, paying, however, such recompense or compensation as may be agreed upon, or if no agreement, as may be settled by arbitration.

25. It shall not be lawful for any such board to remove or otherwise interfere with any milldam, weir, or other like obstruction, whereby the level of the water is raised for milling or other purpose of profit so as to injuriously affect the supply of water, otherwise than with the consent of the owner and occupier of such milldam, weir, or other like obstruction, until their right to do so has been determined by the water court of the district, and until compensation has been made to all parties entitled for the injury which may be caused by such removal or interference.

26. A person who, having a right to or the use of water, or being entitled to superintend or control the use of water, wishes to employ it or to increase its employment for irrigation or domestic use, or the use of stock, or any other useful purpose, is entitled to claim under this act the following servitudes temporarily or in perpetuity, namely: (a) Servitude of aqueduct, (b) servitude of storage (c) servitude of abutment: *Provided*, That (1) a temporary servitude shall not be for a longer period than three years. (2) No proceedings shall be taken for the acquisition of a servitude whilst a dispute as to the right to the water in respect of which the servitude is claimed is pending in a competent court. (3) The servitude shall not give the person exercising it a right of property in the land of the servient tenement, and all burdens attached to the land shall be borne by the owner of the land. (4) No servitude shall be claimed in respect of any water, the right to which is in dispute, until such dispute shall have been settled by some competent court.

27. Servitude of aqueduct shall consist of the right to occupy, for and in connection with the passage of water, such land, the property of another, as may be necessary for the purpose, including the right to construct such works as are necessary for the passage over, under, or alongside of another irrigation work.

28. Servitude of storage consists of the right to occupy, by flooding with water, the land of another by means of a dam constructed on the land of the person claiming the right. The servitude shall include the right of passage over the servitude tenement, along the margin of and throughout the area subject to the servitude, for purpose of maintenance of works, cleansing, clearance of silt, brushwood, or litter, or any like purposes necessary for the due enjoyment of the servitude.

29. Servitude of abutment shall consist of the right to occupy by a dam or weir the bed of a river and the banks adjacent thereto, the property of another, as may be necessary for the dam or weir.

30. A claimant to any of these servitudes must give notice in writing to the owner of the land over which he proposes to acquire the servitude, describing the line of passage along or the locality upon which and the mode in which he proposes to conduct, store, or divert water, or construct works, the works which he proposes to construct upon the land, the compensation which he offers, and the period of time during which he wishes to enjoy the servitude. If the owner does not within one month after the service of the notice agree to the proposals of the claimant, the claimant may apply to the water court for the settlement of the matters in dispute between him and the owner.

31. The compensation for a temporary servitude shall be an annuity equal to the rental value, as nearly as can be ascertained, of the land to be actually occupied by the work when completed, together with yearly compensation for any actual inconvenience and loss that may be exercised by the servitude.

32. The compensation for a permanent servitude shall be a lump sum equal to the average market value, as nearly as can be ascertained, of the land to be actually occupied by the work, together with an annuity as compensation for actual inconvenience and loss that may be suffered by the exercise of the servitude, or, in lieu of this annuity, an amount equal to twenty times the annuity.

33. A temporary servitude may be converted into a permanent servitude by the applicant paying to the owner of the servient tenement such compensation as may be agreed upon or, if there is no agreement, application may be made to a water court for the determination of the compensation.

34. A servitude imposed by order of a water court shall lapse if the work proposed to be executed is not completed and the water is not utilized within three years from the date of such order or within such further period as the water court may have fixed.

PART VII. IRRIGATION LOANS AND GRANTS IN AID.

35. Loans may be granted to irrigation boards or to private owners of land. The security offered by a board must be the rates leviable under the act, or such other security as may be approved by the governor. The security offered by a private owner must be a mortgage on immovable property. An irrigation loan advanced to a board shall be a charge upon the rates of the board, with preference over all other charges.

36. Loans to private owners are divided into three classes:

(a) Loans not exceeding £500 (\$2,425): When the loan does not exceed £500, the amount of the loan, together with any existing mortgages, must be under three-fourths of the divisional council's valuation of the property. If the enhanced value of the property owing to the proposed works is taken into consideration, approved plans and specifications are necessary and the amount of the loan, together with existing mortgages, can not exceed two-thirds of the valuation.

(b) Loans exceeding £500 (\$2,425) and up to £25,000 (\$121,250): When the application for a loan exceeds £500, or the enhanced value of the work is taken into consideration, the director of irrigation is called upon to report to the minister that the applicant proposes to construct the works in a sufficiently substantial and durable manner and in accordance with plans, estimates, and specifications approved of by him.

(c) Loans exceeding £25,000: If the application for a loan exceeds £25,000, or is for a longer period than thirty years, the previous sanction of parliament is necessary, in addition to the director's report referred to in section (b).

37. The period of thirty years is the maximum period for redemption that can be granted without the sanction of parliament and would be allowed only on works of the most permanent class. In the case of pumping and other machinery it would probably be from ten to fifteen years only. The interest charged is $3\frac{1}{2}$ per cent, and the principal and interest are repayable in equal half-yearly installments.

38. The following table shows the amount of the half-yearly payments required to amortize a loan of \$1,000 with interest within the stated periods:

Years in which loan is repayable.	Half-yearly payment.	Years in which loan is repayable.	Half-yearly payment.
Five	\$109.8754	Twenty-five	\$30.1739
Ten	59.6912	Thirty	27.0534
Fifteen	43.1298	Thirty-five	24.8893
Twenty	34.9721	Forty	23.321

In connection with the provisions of the above act and to assist individual enterprise in respect of irrigation, special rebates are given by the government railways upon the carriage of fuel oil for irrigation purposes and materials used in irrigation works.

EGYPT.

Government participation in reclamation work in Egypt is confined, strictly speaking, to the conservation and distribution of water in the public benefit and to the construction and maintenance of the works appurtenant thereto—that is, the dams, weirs, barrages, head-works, together with the main distributing and drainage channels. Consequently, the Egyptian Government is not concerned with the actual operations of land reclamation further than granting concessions, through the ministry of finance, to various private recla-

mation companies. These are somewhat numerous, incorporated land-development companies having multiplied rapidly in Egypt during the last ten years, and are chiefly English joint stock companies having their head offices in London, the most important of these being the Aboukir, the Kom Ombo, and the Behera companies.

The Aboukir Company has operated for several years under government concession, a large tract of land in the vicinity of Lake Mariut (ancient Mareotis). The land lies for the most part at or under sea level and, owing to its proximity to the ocean and possibly having anciently formed part of the sea floor, is strongly impregnated with salt. The operations of the company consist chiefly in washing the salt out of the soil by repeated floodings, the run-off being taken up by catch ditches, which discharge into the main drainage canals of Lake Mariut, whence the water is pumped into the Mediterranean by the government pumping plant at Mex. When the soil has by this means been brought into a condition capable of profitable cultivation, the land thus reclaimed is sold to private parties in tracts of varying extent. In this manner all but about 4,000 acres of the concession have been disposed of.

The Behera Company was originally a pumping company which for several years, during the unsound and leaky condition of the Cairo Barrage, held a government contract for delivering water into the canals above the barrage. After this was repaired by the British engineers the need for the Behera pumping plant no longer existed, and in consideration of the surrender of their contract a large tract of public land was assigned in fee simple to the company, which now controls and operates it.

The Kom Ombo Company operates in Upper Egypt, and obtains the water necessary for the development of its concession by pumping directly from the river. The company has two pumping stations, and the pumps installed there are said to be the largest of their kind. The Kom Ombo concession covers about 50,000 acres, of which, however, owing to difficulties caused by the absence of humus and the sandy surface deposits, only about 5,000 acres have been hitherto put in cultivation.

IRRIGATION WORKS IN EGYPT.^a

The most important of the operations of the department during the year reported on have been the conversion works in middle Egypt, the talus work on the Aswan Dam, and the construction of the Isna Barrage.

The conversion works in Middle Egypt will, when completed, change from basin to perennial irrigation an area of 416,600 acres, of which 301,750 acres have already been converted. The total estimated cost of these works is \$21,000,000, of which \$12,150,000 was spent up to the end of 1906. The actual benefit which has, up to the end of 1906, resulted to the country from these works is estimated to be a rise of rental value of \$8,850,000, and of sale value of \$117,945,000. These figures may seem large, but they are in no way exaggerated.

The total expenditure on the conversion works of Middle Egypt amounted to \$3,482,165, and the following quantities of work were executed in connection therewith:

Earthwork.....	cubic feet..	416, 321, 704
Masonry work.....	do.....	18, 179
New canals.....	miles..	226. 178
New drains.....	do.....	193. 866
Lands expropriated.....	acres..	1, 790

^a From the administration report of the irrigation department in Egypt and the Sudan for the year 1906.

The Talus Work at the Aswan Dam.—The severe action of the water, after issuing from the under sluices, eroded deep holes in the granite rock which forms the river bed downstream of the dam. Some of these holes were several meters deep and of considerable size. In some cases they approached closely to the foundations of the dam.

Although the structure was at no time in any danger, it would have been highly imprudent to have permitted the erosion in the river bed to continue, and it was consequently decided early in 1905 to undertake protective measures upon a large scale by removing all inferior rock in the vicinity of the dam and filling all the holes worked by water with granite masonry. It was also decided to construct an apron of the same material downstream of the dam and throughout its length.

The process was as follows:

The deep channels in the river were closed early in the season, and the spaces inclosed were pumped dry. It was found that erosion had taken place almost everywhere, even where the surface rock was apparently of the soundest description. The bottom of some of these holes descended to a level below that of the foundation of the dam itself. The method generally employed for repairing the damage done was as follows: The whole of the loose bowlders and bad rock were blasted and removed down to the solid rock, often below the foundations of the dam itself; in the deepest channels this was a work of considerable difficulty. Masonry was then commenced and the whole filled with cement-granite masonry to within 50 centimeters of the floors of the sluices. The last stone was laid on July 20, when a continuous talus was completed, of a width varying from 30 to 60 meters (98.42 to 196.85 feet), as was considered necessary, underneath all the sluices and for the whole width of the river except under one set of sluices, where a water cushion has been formed by the construction of a cistern.

The number of workmen employed during the season varied from 2,000 to 5,000 men, including 500 Europeans.

The surface of the talus is faced with dressed rubble, and the apron is divided into compartments by cross walls running at right angles to the line of the dam, the object of these walls being to facilitate the examination of the apron below any particular group of sluices. The difference in the action of the water as it passes from the sluices is easily discernible from the photographs of the completed talus.

In this connection the following quantities of work have been executed:

Excavation.....	cubic feet..	9, 957, 850
Masonry.....	do.....	4, 802, 717
Facework.....	square yards..	72, 956

at a cost of \$1,413,515, which, added to the cost of the ironwork, gives a total expenditure of \$1,517,875.

The Isna Barrage.—In order to improve the irrigation of the Keney Province during flood, it was decided to construct a barrage across the Nile immediately above the town of Isna.

The barrage will be an open weir of 120 bays, each 5 meters (16.404 feet) wide; abutment piers 4 meters (13.12 feet) thick occur at every tenth opening, the intermediate piers being 2 meters (6.56 feet) thick; the piers are spanned by arches carrying a roadway 6 meters (19.68 feet) wide. Two regulating gates, one upper and one lower, each 3 meters (9.84 feet) high, will be provided for each opening; double grooves will be so arranged as to allow both gates to drop onto the floor—thus, the upper gate will act as a weir with a movable crest.

On the western side a lock 16 meters (52.48 feet) wide, large enough to pass the largest steamers on the Nile, will be provided. The design is similar to that of the Asyut Barrage.

Drainage in lower Egypt.—The work of remodeling by dredging the outfalls of the main drains and the realignment of many of the smaller branches was steadily continued. Arrangements are being made to introduce small dredgers into some of the drains which it is impossible to clear by hand work. The present pumping power at Mex keeps Lake Mareotis under control, and the variations in level during the last five years are not important. The quantity of water pumped during the year reported on was 410,000,000 cubic meters (14,478,940,000 cubic feet=332,390 acre-feet), at a cost of \$73,395, or \$5.07 per 1,000,000 cubic feet.

Sudan irrigation service.—The bulk of the work of this service consisted of a continuation of the leveled surveys of the river and adjacent country, a work

of extreme difficulty, owing to the obstructions of swamps, sadd (weed), and thorn bush. The chief object of the studies prosecuted by the service is to ascertain what is the best and most economical method of obviating the excessive waste of water that at present occurs in summer in the Gebel marshes, and at the same time of preventing a largely increased flood supply from passing down the river channel. These marshes at present act as a most effective escape for the flood water, but they also suck up the summer supply and greatly diminish its volume. What is required is a scheme that will enable us to escape the flood water, as at present, into the marshes and at the same time secure the passage of the summer water down the river in undiminished discharge.

Whether the scheme eventually selected will take the shape of a new cut for the river or will consist merely of enlarging and remodeling the existing channels can not yet be predicated, but it is evident that, owing to physical and climatic causes, the preparation of the projects will take considerably longer than was at first anticipated. Until the surveying staff have completed their task, no definite proposals or suggestions can be made. The work, when finally undertaken, will be one of the most important ever taken in hand by hydraulic engineers. It will mean interfering with nature over an extended area of country and altering the regimen of a large river upon a scale larger than has ever yet been attempted. It is imperative that before coming to a decision the fullest information possible must have been obtained.

THE TRANSVAAL.

GENERAL STATEMENT.

To understand the problems confronting the irrigation department in the Transvaal, some knowledge of the hydrographic conditions of the country is absolutely requisite. The Transvaal, which is bounded, politically speaking, on the south by the Orange River Colony and Natal, on the north by Rhodesia, on the west by Cape Colony and Bechuanaland, and on the east by Portuguese East Africa, has for its principal hydrographic boundaries on the south the Vaal River, on the west and north the Limpopo, while on the east several small rivers traverse its boundary on their way to the Indian Ocean. About 90 miles from its eastern boundary is the Drakensberg, the principal mountain range, from which a steep escarpment descends toward the east; to the west the country falls gently. The main watershed between the Vaal and Limpopo rivers runs nearly due east from the Drakensberg, across the colony, and at an average distance of about 60 miles from its southern boundary. The general fall from south to north, while gradual, is considerable.

Physically speaking, the country is divided into four districts, each with marked distinctive features—the High Veldt, the Middle Veldt, the Slopes of the Plateau, and the Low Veldt.

The High Veldt has an altitude of from 5,000 to 6,400 feet above sea level and forms the extreme eastern summit of the great South African table-land; it is about 140 miles long from east to west, about 120 miles from north to south, with an area of about 17,000 square miles. It is uniform and monotonous in character, consisting of rolling country, with wide rises and broad shallow depressions. It is naturally treeless, but clothed with short sweet grasses. In this area perennial running water is very rare, but the valleys have streams in them during the rainy season. There are no defined ranges of hills, but occasionally hillocks, known as "kopjes," emerge from the surrounding veldt. To the east are several depressions, known as "pans," some of which hold water, usually brackish, all the year round, but

most are dry during the fair season. The soil of the High Veldt is not rich, but can be tilled in large areas and is not too poor to repay cultivation.

The Middle Veldt has an altitude of about 4,000 to 5,000 feet above sea level and constitutes the remainder of the plateau. It lies chiefly to the west of the High Veldt and covers about 28,000 square miles. Generally speaking, it is of the same character as the High Veldt, but is traversed by long low ridges known as "rands." Pans are less frequent, but water courses, either running or dry, are of common occurrence. The country is generally treeless, but scrub occurs over the rands and mimosa in the valleys. The grass is of inferior character for stock purposes. The soil, being derived from nonacid rocks, is richer than on the High Veldt, but owing to the stony outcrops and rocky dikes can not so conveniently be cultivated.

The Slopes of the Plateau extend about 35 miles north of the Middle Veldt and about 60 miles east of the High Veldt; their area is about 23,000 square miles. The central part of their northern section is traversed by three main ridges, the Witwatersrand, the Witwatersberg, and the Magaliesberg, the first of which is the watershed between the Atlantic and Indian oceans and contains the gold mines of the Transvaal. In this section the country descends by a series of ledges parallel to the main ridges, and even the large rivers in it have only a small perennial flow. The eastern falls away rapidly with very steep slopes, consisting of sedimentary rocks at the crest and igneous rocks, chiefly granite, at the base. The country is extremely rough, intersected by numerous valleys, in all of which are perennial streams of fair size. The valley bottoms are well wooded with mimosa and other trees. The arable land chiefly consists of narrow stretches in the valleys; it is of excellent quality, but, being in isolated patches, can not be irrigated on an extensive scale.

The Low Veldt comprises the rest of the Transvaal and has an area of about 43,000 square miles. At the north of the plateau it has an elevation of about 4,000 feet, falling gradually to about 2,000 feet at the Limpopo. To the east it slopes away to 1,000 feet at the Portuguese border. The Low Veldt is flat and covered with thorny scrub bush, useless except for firewood. Along the river courses some timber trees are found. Water is very scarce in the Low Veldt, and the rivers which traverse it diminish in volume and even disappear altogether. To the north are several so-called "sand rivers," which flow only after the rains, for short distances, and are then gradually absorbed. The Springbok Flats, a notable area near Pretoria, about 20 miles wide and 130 miles long from southwest to northeast, is a waterless and almost treeless belt of black "cotton soil" derived from the underlying amygdaloidal diabase. Several experiments have been and continue to be made with the object of supplying water to the Springbok Flats, which, if they could be irrigated, would become one of the most productive areas in the country.

As a general rule the rainfall may be said to decrease with the elevation of the country and its distance from the Indian Ocean. On the Low Veldt the average annual fall is from 20 to 40 inches; on the crest of the Slopes of the Plateau it approximates to 60 inches; on the Middle Veldt it varies between 20 to 25 inches, and on the High Veldt the average is 30 inches. These figures are mere approxima-

tions, systematic observations having been conducted only during the last three years, or since the establishment of the irrigation department. Usually speaking, the western Transvaal depends for its precipitation chiefly upon local thunderstorms.

The predominant characteristic of the rainfall is its frequent great intensity and short duration; the bulk of it descends in short heavy showers. From the records of the government observatory at Johannesburg, where the rainfall on the central Witwatersrand has been recorded for the last ten years, it is seen that over 80 per cent of the total precipitation falls in heavy showers of more than one-fourth of an inch. Almost exactly one-third is contributed by heavy falls of between one-half and 1 inch, and nearly one-quarter by those of more than 1 inch. These facts have an important bearing upon the irrigation of the colony, since run-off and consequent loss in sinks and sand patches after those heavy falls is much greater proportionally than after the slight showers.

Irrigation of some sort, as a means of increasing the fertility of the soil, has been in use in the Transvaal ever since the advent of the first white settlers. When the "voortrekkers," as these men were called, came from the cape to the land "across the Vaal," they settled first along the rivers which were most suitable for irrigation. As the numbers of the newcomers increased and the scarcity of advantageous positions from an irrigationist's point of view became known, the value of irrigable land with a water right rose rapidly, so that as much as \$500 an acre has been paid for such land, where the adjoining dry land would not fetch as much as \$5. Upon such farms fancy prices are placed, and they are rarely obtainable.

The original settlers naturally constructed only works of a primitive character; across the streams sod and dry-stone dams were thrown, and from them "water furrows" were led mostly in a haphazard manner, without alignment of close grading. Some of the more enterprising farmers are now endeavoring to construct more important works, but are hindered by the provisions of the existing water law^a and the insufficiency of the natural supply. Although the works are individually small, they are numerous, and so the total area under irrigation is considerable.

The Boer Government did practically nothing in the way of scientific irrigation. The only serious attempt at work of this character was the construction of an earthen dam at Wolmaransstad, in southwestern Transvaal, just before the war, in order to store water for the irrigation of the town lands. This reservoir was never brought into operation, owing to the faulty design and dangerous condition of the dam, which constituted a menace to property below it, and in January, 1904, it was cut through to prevent its being breached. At Schweizer Reneke another earthen dam was commenced just before the war; the design was equally faulty and dangerous. No other storage works were planned nor any schemes for the utilization of the flow of perennial streams for purposes of irrigation. Boring for water was practised by individual farmers, but the Government did not take any steps with regard to that matter.

^a The existing legislation in respect of riparian and water rights in general is very faulty and incomplete and has stood in the way of progress along irrigation lines. After three years of discussion, a water bill which, it is hoped, will do away with most of the difficulties and abuses, has been drawn up and is to be presented this year before the legislature.

About the middle of 1901, Lord Milner, then high commissioner for South Africa, invited Sir William Willcocks, a well-known authority upon Indian and Egyptian irrigation, to visit the country and report upon the irrigation conditions. Sir William made an exhaustive report and recommended that the state should undertake the construction of irrigation works on a large scale. In January, 1903, after the country had begun to settle down on the conclusion of the war, Lord Milner asked the Indian government to lend one of their engineers to start an irrigation department in the Transvaal, and Mr. W. L. Strange was detailed from the Bombay irrigation branch for three years^a for that purpose. Mr. Strange lost no time in organizing a working irrigation branch. Experienced men were detailed from India and Egypt to assist the director, a hydrographic survey branch was established, and reconnaissances and cadastral surveys of the various catchment areas begun. A hydrographic survey branch was formed, and the flow of all the perennial streams accurately recorded. At the close of the four years of Mr. Strange's work in the Transvaal, a mass of working data concerning the hydrographic conditions of every catchment area in the Transvaal had been secured, working plans for nearly 40 projects drawn up, and two irrigation works constructed and operated, supplying about 5,000 acres. In his remarks upon the work of the irrigation department, the retiring director says:

The department has not had an opportunity of showing of what it is capable, except in the matter of boring and waterworks, and has had to be satisfied with preparing for the future. * * * These preliminary investigations will enable it to proceed hereafter with greater certainty and economy in constructing works for the agricultural development of the country. The importance of acquiring hydraulic data, of investigating numerous schemes from which a selection can be made for execution, and of training the staff, can not be over-estimated. Of all branches of engineering it may be said that such preliminary work is most necessary in irrigation in order to avoid the expensive mistakes which have been committed not only in South Africa, but elsewhere, and it is doubly important in the Transvaal, where practically no irrigation works on the extensive and scientific scale necessary have been carried out. It is of course disappointing to the staff that in the first four years of the existence of the department so little construction work has been carried out * * * but it is hoped that with a larger number of members of the legislature interested in agriculture, proper irrigation development will be started at an early date, and that its progress will be continuously maintained.

The following account of the Christiana Project, one of the most important under consideration, is abbreviated from the director's report.

CHRISTIANA PROJECT.

This consists of a storage weir to be built across the Vaal at the head of a rapid having a total drop of 10 feet, where the foundation is good. The foundations of the main weir will be protected by a masonry cushion weir built 600 feet downstream. Provision has been made for a maximum flood discharge of 500,000 cusecs, which is equal to a run-off of 11.5 cusecs per square mile of the catchment area. The weir will have a maximum height of $31\frac{1}{2}$ feet, so that the canals will soon pass out of the high-flood margin of the river. Initial bed level of canal will be 10 feet below its crest and full

^a Afterwards extended to four. Mr. Strange finally left the Transvaal in June, 1907.

supply depth will be 5 feet. The project provides for irrigation of 17,000 acres on the Transvaal and 8,000 acres on the Orange River Colony side of the Vaal. At the right flank of the weir will be undersluices, 6 by 4 feet, to keep clear the approaches to the canal head regulator, which is in continuation of the sluices and is also pierced by 6 by 4 foot sluices for regulating supply to the canal. The canal will have an initial bed width of 16 feet and will be 34 miles long. The following works are proposed in connection with it; 1 steel aqueduct of five 25-foot spans, 27 combined superpassages and road bridges, 1 flood regulator, 8 natural escapes, 8 scouring sluices, 1 road bridge, and 2 railway bridges. The estimate provides for distributaries and outlet heads, minor cross-drainage works, fencing and plantation on both sides, an inspection road, mile and furlong stones and quarters for the staff.

An alternative scheme for this project is to reduce the length of the overfall portion, so that the high-flood depth over it will be increased to 14 feet and to construct on top of the crest an arcade of 30-foot spans which can be closed during the dry season by shutters 14 feet high, the full supply level of the reservoir being therefore the same as the high-flood level over the weir. By this plan the storage capacity of the weir will be increased from 2,187,000,000 to 11,451,000,000 cubic feet, the length of the backwater from 62 to 100 miles, and its irrigating capacity from 17,000 to 90,000 acres. Under the original scheme, the cost of the works would be £24.60 per acre; under the larger one, £12.71 per acre.

The estimated cost of the irrigation projects in the Transvaal is high. A general review of the projects gives the average per acre as £24, or \$116.40. This is probably due to two main causes: The great distance from the manufacturing centers, all machinery and metal work having to be brought from Europe or America; and also the peculiarly unfavorable physical conditions, such as the narrowness of the irrigable lands bordering on the rivers, necessitating an expensive canal system, the frequent gullies and fissures, and the careful provision requisite for properly storing and safeguarding against the flood waters. With all these disadvantages, it is noteworthy that the director states that there is every prospect of irrigation in the Transvaal being sufficiently remunerative to justify prosecution.

Toward the close of 1903 the work of boring was begun by the department, primarily with diamond drill, to ascertain the geological formations, but afterwards as part of the irrigation projects of the department; and this branch has been, from the popular point of view, the most successful of all. During the first two years it was found very difficult to induce the Boer farmers to take interest or place confidence in the device, and the government operations were confined to departmental and municipal borings; the success of these latter convinced the farmers that the scheme was a practical one, and during the last two years 130 holes have been bored for farmers in all parts of the country. The result in yield of water has been quite satisfactory; but the cost of boring, like that of the projects, appears distinctly high, the average being \$7.50 per foot. As most of the wells are quite shallow—only 1, out of the 250 bored to date, being over 300 feet deep, and fully one-half of them under 150 feet—the expense does not seem fully accounted for by the explanation that the formation is a peculiarly difficult one, the

working cost being probably largely increased by the expense and difficulty of transportation, the high scale of wages, and the lack of skilled drillers. The strata in the Transvaal are described as "very hard; dolomite, chert, granite, diabase, quartzite, etc.," sandstone and shale being rarely encountered. The cost chargeable to the farmer is one-third the cost to the Government, the rest being provided for in the budget of the irrigation department. This averages about \$2.50 per foot, including casing. In addition, he has to provide transportation from farm to farm, and fuel and water. The percussion drills used are Austin No. 2, Clipper No. 2, and Star No. 1 and No. 3. No rotary drills appear to be used.

THE WATER BILL OF 1908.

One of the chief difficulties in the way of progressive irrigation work has been the unsatisfactory condition of the law, or rather the absence of legislation defining the rights of riparian proprietors and of the public in respect of the water of the public streams. In this regard the third chapter of the water bill now before the legislature (which, in its other provisions, differs little from the water act of Cape Colony) is of interest.

CHAPTER III. USE OF PUBLIC AND PRIVATE WATER.

(1) Every proprietor shall be entitled to use exclusively and without restriction all water rising naturally on the land held by him in so far as such water has not reached a public stream or does not form the source or part of the source of a public stream.

(2) All water which falls or naturally drains onto the surface of land shall be the sole and undisputed property of the proprietor thereof as long as it remains upon such land and does not join a public stream.^a

(3) All water which joins or forms part of a public stream shall be public water, the use of which, subject to rights lawfully acquired, shall be regulated by this act. There shall be no right of property in public water save as is otherwise provided in respect of surplus water (sec. 6).

(4) Public water shall be subject to primary, secondary, and tertiary uses.

The primary use of public water shall be the use necessary for the support of animal life and, in the case of use by riparian proprietors, the use necessary for domestic purposes.

The secondary use of public water shall be the irrigation of land under cultivation.

The tertiary use of public water shall be for mechanical or industrial purposes.

An upper riparian proprietor shall not be entitled to the secondary use of public water if he thereby prevents its primary use by any lower riparian proprietor.

Subject to the provisions of this act and to rights lawfully acquired, an upper riparian proprietor shall be entitled to divert a reasonable quantity of public water for its secondary use, provided he does not infringe the rights of any lower riparian proprietor to such use, and returns the same at a definite place to the public stream with no diminution other than is caused by the secondary use.

In determining what is a reasonable secondary use regard shall be had to the relative extent of the upper riparian and lower riparian farms, the area and situation of ground cultivated and capable of being cultivated, the extent of river frontage of each riparian farm, the method of user, the flow of the public stream, and the rainfall over an area.

^a "Public stream" is defined as "a natural stream of water which (a) in ordinary seasons flows for the greater part of the year in a known and defined channel, whether or not such channel is dry during any period of the year; and (b) is capable of being applied to the common use of riparian proprietors."

The tertiary use of public water by an upper riparian proprietor shall be subject to reasonable secondary use of public water by all lower riparian proprietors.

No person shall have the tertiary use of public water to develop power greater than ten horsepower or for any other purpose without the consent of the river board, which may, subject to the provisions of this act, or the regulations and the approval of the governor, permit such use on terms and conditions to be specified by it.

(5) If the river board is satisfied that during any period of the year all the water of a public stream can not be used by all the riparian proprietors, it may grant permission for the diversion, during such period, of the surplus water ^a of such stream: (a) Onto nonriparian farms within the catchment area of such stream; or (b) across the watershed of such stream into another catchment area in which the surplus water can be usefully employed for irrigation or other purposes: *Provided*, That (1) a riparian proprietor is not thereby deprived of water necessary for land which is, at the time, under irrigation, or might thereafter reasonably be expected to be brought under irrigation; (2) in the grant of the permission, preference shall be given to farms described in paragraph (a) of this section.

(6) Written permission may be granted by a river board, subject to the provisions of this act or the regulations, to any person to store the surplus water of a public stream. An appeal shall lie to the minister against the grant or refusal of such permission.

Every person authorized under this section to store surplus water shall be entitled to the property in such water and notwithstanding that the surplus water be left to mingle with the other water in a public stream.

(7) Any diversion or storage of surplus water under the last two preceding sections shall be at a place described in the permission, which shall also specify: (a) In the case of diversion the line of passage of the water; (b) the nature of the diversion or storage works; (c) the amount of compensation, if any, to be paid to any proprietor on whose farm it is stored or through or over whose farm the surplus water is diverted or conveyed for storage.

ARGENTINA.

There is not one of the South American republics in which the reclamation of land and its beneficial use is more directly concerned with the national welfare than Argentina. The immense stretches of prairie, at present covered with an uncertain growth of herbage, but responding marvelously to irrigation, the intermittent character of the rainfall, and the frequent natural facilities for water storage offered in the many upland valleys, the numerous rivers which intersect the country, whose low banks present special advantages for weirs and intakes, and, in sum, the general topography of the whole country, make the conditions exceptionally favorable for the utilization of the abundant water supply to the advantage of the agricultural interests of the Republic. At the same time the need for irrigation in certain districts of the States is undeniable; the productiveness of the province of Cordova could be enhanced immensely if the atmospheric deposits of the summer months could be stored and judiciously applied throughout the year, and the greater part of the Andine provinces, where hardly any rain falls between November and April, could be turned into a region of unsurpassed fertility by the application of similar methods.

It is admittedly unfortunate that the participation of the Government in this department of national economics has hitherto been of a spasmodic and, so to speak, academic character. In a few instances

^a "Surplus water" shall mean any water in a public stream in excess of the normal flow of such stream, and any water which, not being required for the uses described in (4) on riparian farms, would otherwise run to waste.

subsidies have been granted—not always with due precaution and possibly never with subsequent supervision and control; considerable sums have been also expended in hydrographic survey work, and foreign engineers have been invited to make examinations of the natural resources and report upon them—the engagement a few years ago of the Italian engineer, Cipoletti, to make a survey of the basin of the Rio Negro and report thereon with a view to utilizing its waters for irrigation (a report which has not yet been acted upon) is a case in point—but no settled policy has ever been adopted with regard to irrigation, and it is only quite lately that the Government, by laying before the Chambers a plan—to be discussed later—involving the appropriation of about \$12,000,000 as an irrigation fund, has shown a serious appreciation of the important national issues involved in irrigation conceived and carried out upon the scale which the physical features and the natural water supply of Argentina render possible.

To give an idea of the natural advantages of the country for irrigation methods, it may be stated that the report of Cipoletti affirmed that an area of about 2,500,000 acres could be irrigated by the Rio Negro and its tributaries at an estimated cost of about \$1.25 per acre, a capital outlay which would be recovered many times over by the increased value which irrigation would bestow upon the state lands benefited thereby.

The possibilities of extensive irrigation are not confined to the basin of the Rio Negro. A survey of portions of the irrigable area of the province of Cordova, where at present about 250,000 acres are under irrigation, established the fact that at comparatively small expense it would be possible to store sufficient water to irrigate over 1,225,000 acres in addition to the area at present irrigated. In this province, on the River Prunero, is the San Roque dam, a masonry structure 120 feet high and 377 feet in length, impounding within a lake 3,000 acres in extent, about 8,820 million cubic feet of water (over 200,000 acre-feet), but with all this storage capacity, only some 25,000 acres, all lying in the department La Capital, are irrigated.

Most of the irrigated land is provided with water by means of intakes directly from the rivers, of a primitive character, consisting usually of a small diversion weir, constructed of piles, interlaced with branches and brushwood run out into the river, and being little more than the extension into the stream of the outer wall of the "toma" or intake itself. The physical conditions are usually such that large and regular supplies can be derived in this manner and without further difficulty; where the slope of the land is more rapid, check weirs similar in character to the "toma" are constructed along the canal. These primitive constructions, being without solidity, are frequently damaged and sometimes carried away entirely at the periodic freshets, and their rebuilding and maintenance constitute a heavy annual burden upon the inhabitants of the irrigated districts.

In the province of Buenos Aires, which has for many years suffered severely from droughts and floods—the extensive cattle interests being the principal losers—an important canalization scheme, the Canal del Norte, was started several years ago by the department of public works, but from different causes never completed. An official report lately handed in by the government engineer in charge of the works gives the following particulars concerning the Canal del Norte.

The canal consists of two distinct sections—the first from Baradero to Salto, 80.8 miles long, composed of the rivers Baradero, Arrecifes, and Salto, regulated and turned into navigable canals by means of weirs and locks, the channels being corrected and dredged where necessary.

The second section, 79 miles long, which extends from Salto to the Mar Chiquita, and passes through the Chacabuco region and the town of Junin, is a dug canal provided with locks. Owing to defective construction, the object for which the canal was constructed—the supplying of water throughout the semiarid parts of the province in seasons of drought—can not be carried out, and as the amount of the original subsidy, some \$4,000,000, has been entirely expended, a large additional grant is called for to save the whole project from complete failure.

It is stated that one of the members of Congress from the province of Mendoza is shortly to present a bill authorizing the damming of two rivers in this province, the Mendoza and the Tunuyan. The former irrigates regularly 113,500 acres, and 45,000 acres in addition at times of flood, and the latter irrigates regularly 192,600 acres, and 56,000 acres more during flood; and it is estimated that the storage provided by the dams would increase the irrigable area by more than 400,000 acres. There are about 820,000 acres under cultivation in this province, including some 84,000 acres of vineyards, estimated at about \$40,000,000, the value of the remainder being placed at about \$52,000,000. It is expected that the construction of these dams would increase the value of the irrigable property in the province by about \$130,000,000.

In the province of Santiago del Estero the provincial government has lately voted an appropriation of \$86,000 in five monthly installments for the purposes of irrigation, the sums appropriated to be expended in repairing and improving existing works and in the construction of additional canals and weirs.

The irrigation law already referred to, which the minister of public works has laid before the National Congress, is as follows:

PROPOSED IRRIGATION LAW.

ARTICLE I. The executive power is hereby authorized to prepare the necessary plans for a system of irrigation works in the provinces of San Luis, La Rioja, Catamarca, Salta, Jujuy, and Santiago del Estero, in the zone of the national railways, up to 31 miles on either side of the permanent way, provided the said provinces accept the benefits of this law.

ART. II. A sum of \$260,000 may be applied out of the general revenues toward the completion of said project.

ART. III. As soon as the plans have been completed and approved, the executive power will begin the construction of the works, either by the department or by inviting bids for the same according to the requirements of each case.

ART. IV. Land required for the construction of embankments, canals, and works accessory thereto is hereby declared expropriable for the public benefit. All machinery, material, implements, and other requisites for the construction authorized by this law shall be exempt from import duties, the minister of public works determining what material, machinery, implements, etc., are necessary, and requesting exemption therefor.

ART. V. Upon the completion of each project the executive power will fix a term for the official registration of the properties to be benefited by the irrigation in such a manner as to irrigate them conveniently according to the amount of water available.

ART. VI. The owners of the lands included in the register shall pay to the administration the respective quotas fixed by the executive power; the estimate of these being based upon the cost of the work and the productive capacity of the lands irrigated, in order that the capital outlay required for the construction may be recouped within a reasonable time.

ART. VII. The owners of lands included in the register, who shall have complied with the obligations of the above article, shall thereby obtain preferential and perpetual rights to the use of the water for irrigation purposes in sufficient quantities for the lands included in the register.

ART. VIII. As soon as the distribution of the water has been fixed for the area which can be irrigated with the quantity of water which the canals can carry, these waters may not be deviated from their natural sources nor used to supply other lands, if such deviation is prejudicial to the landowners who have previously secured preferential water rights.

ART. IX. The preferential rights secured for irrigation shall be understood to apply to the lands officially registered, and in case the obligations of the proprietors are not complied with the executive power may proceed to sequester the said lands.

ART. X. When the works constructed serve for the better utilization of waters already in use for irrigation, a right to the said use having been previously legally acquired, the lands already thus irrigated shall retain their preferential rights to the use of the water in the quantity already necessary for the area previously irrigated, and they shall be registered and pay a share of the cost of the works proportional to the benefit derived from the new works.

ART. XI. The executive power may construct works for the development of motive power derived from waterfalls, or may lease them for limited terms to private corporations.

ART. XII. When the capital invested in the works shall have been recouped by the receipts, the works shall be turned over to the provinces concerned, which shall undertake their maintenance and management.

ART. XIII. The executive power shall issue decrees for the distribution of the water in accordance with the provisions of this law and taking into consideration the agricultural conditions of each locality.

ART. XIV. For the execution of these projects an irrigation fund shall be established, for which the following provision is made: (1) Twenty-five millions of dollars (about \$11,000,000 gold) to be obtained, if necessary, by the sale of the Andino Railway, as provided in law 4054. (2) The amounts received for the allotted quotas of water right. (3) The revenue from the motive power and other industrial factors developed from the water.

In the preamble to the bill, which bears the signatures of the President and the minister of public works, it is stated that "so far, irrigation works have only been undertaken in a casual way and artificial aqueducts of every kind have been opened up without following any rational plan, complying only with the need of the moment. * * * This project embraces at the same time a plan for the better development of the railways which pass through the provinces and which are the property of the nation."

The dual significance of this agronomic project is noteworthy.

CANADA.

GENERAL STATEMENT.

All public irrigation works in Canada are carried out by the corporations or persons interested, subject to the conditions of an agreement between the minister of the interior and the persons forming or representing the company. When public lands are purchased from the State, whether by municipalities, corporations, companies, or private individuals, for the purpose of installing an irrigation system and applying it to the lands thus purchased, the Canadian government will credit the total cost of the irrigation works on account

of the purchase money to be paid for the land, but not so as to exceed an amount equal to \$2 per acre of the total number of acres purchased. The regular price for government land is \$3 per acre. Another proviso is that a certain proportion of the total acreage must actually be irrigated. This proportion varies according to the circumstances of the case; in that of the Robins Irrigation Company, which purchased nearly 400,000 acres in South Saskatchewan, the stipulation was that at least one acre in four should be irrigated.

The chief irrigation districts of Canada are in South Alberta and South Saskatchewan, and the most important enterprise which has been undertaken by a railway now in course of construction. This project embraces a tract of about 3,000,000 acres, only one-fourth of which, however, is regarded as capable of being irrigated. This land forms part of the railway construction grant, and therefore no order in council was needed to authorize the construction of the irrigation works.

The Alberta Railway and Irrigation Company's project involves the construction of about 200 miles of main and subsidiary canals and is intended to irrigate about 200,000 acres.

The Canadian government makes investigation of the flow of the streams in the different irrigation districts, and the superintendent of irrigation issues annual reports upon the subject, all of which are supplied to the public upon application.

All irrigation works of a public character are subject to the conditions of the "Northwest Irrigation Act" of 1898, which superseded the previous act of 1894, and of which the main provisions are as follows:

MAIN PROVISIONS OF THE NORTHWEST IRRIGATION ACT OF 1898.

The property in and right to the use of the water of water courses, lakes, marshes, etc., shall be deemed vested in the Crown except in so far as some right therein, which is not a public or common user right, is established, and no diversion of water is permitted except under the provisions of this act. No right to the permanent diversion or exclusive use of such water can be acquired by any riparian or other owner by user or otherwise except under the provisions of the act, unless it is acquired by a grant existing at the time of the passing of the act.

All water-right holders or persons operating works for the utilization of water must obtain a license before the 1st of July, 1898.

Right to use water may be acquired for three purposes: (1) Domestic purposes, which includes stock water and water for industrial use, but not for sale or barter; (2) irrigation purposes; (3) other purposes.

No rights in the use of water shall be granted which would interfere with the domestic needs of persons owning adjoining lands.

Persons contemplating irrigation works must apply for a license to do the preliminary work, make surveys, etc., and must, in their application, set forth full particulars, with all necessary plans, of the contemplated project. Public notice of the filing of the application must be made by the applicant in the local newspapers not less than once a week for thirty days, during which time protests may be filed.

If the application and plans are approved, a license to construct the works in accordance with the plans will be granted, and in such authorization the term within which the works are to be completed will be fixed. No deviation from the original plans may be made without permission.

All works so authorized are subject to inspection by the chief engineer or other officer, at the expense, if the minister so decides, of the constructing company or persons; and such inspections may also be made upon the application of any person residing on or owning land in the neighborhood of such

works, the applicant in this case to deposit a sum sufficient to defray the cost of the inspection, the decision as to whether the applicant or the company pay the costs lying with the minister.

Construction work shall commence not later than two months after the license is issued and shall proceed continuously until sufficiently completed to supply water to all applicants within the area prescribed, and the minister or his designated representative shall be the sole arbiter as to whether the work is being prosecuted with sufficient vigor.

For reasons which he deems sufficient, the minister may grant an extension of time for the commencement or completion of the works. Any works uncompleted on the expiration of the time limited for their completion may be taken over and operated or disposed of by the minister, compensation being paid for such works at their value, such value being ascertained by reference to the exchequer court or by arbitration, one arbitrator to be named by the governor in council, the second by the licensee, and the third by the two so appointed; or in case of nonagreement, by the exchequer court, and in estimating such value the court or the arbitrators may take into account the expenditure of the licensee and interest on such expenditure and the value of his property, works, and business; provided that no person who at such date is using the water of the said works shall be deprived of the amount of water he is entitled to.

Upon the expiration of the time limited for the construction of the works, the chief engineer shall cause them to be inspected, and if the inspection proves satisfactory a certificate shall be issued by the chief engineer and forwarded to the department setting forth that the works have been completed in accordance with the application; that the necessary right of way has been obtained; that agreements have been entered into for the supply of water for the irrigation of lands which are not the property of the licensee, and that the works are capable of carrying and utilizing a stated supply of water. Upon the receipt of this certificate the minister shall issue a license to the applicant for the quantity of water to which he is entitled.

Licensees shall have priority among themselves according to the order of their licenses, and the minister or officer authorized by him shall receive complaints and settle disputes between licensees as to the water to which each is entitled.

When the works are not of sufficient capacity to carry the amount of water acquired by their owner, his exclusive right shall be limited to the quantity which his ditch, flume, or other contrivance is capable of carrying, and the finding of the inspecting officer as to the capacity thereof shall be final and conclusive.

Every person who willfully, without authority, takes or diverts water which he is not entitled to, or takes or diverts a greater quantity of water than he is entitled to, is guilty of an offense, and is liable to a fine not exceeding \$5 per day for each cusec or unit of water improperly diverted, or to imprisonment for not longer than thirty days, or to both. This applies equally to licensees.

Any licensee shall dispose of any surplus water flowing in his works which is not being utilized for the purposes authorized to any person applying therefor for irrigation purposes and tendering payment in advance for one month at the regular prices.

Persons so applying shall pay an amount equal to the cost of the works required to convey the surplus water to them, or shall themselves construct such works, and when the works have been constructed and the tender made as above the applicant shall be entitled to the use of as much of the surplus water as such works have capacity to carry. But such applicant acquires thereby no right to the said surplus water when it is needed by the licensee for the purposes authorized, nor can he waste, sell, or dispose of the same, nor prevent the original owners from retaking, selling, or disposing of the water after it has been used as aforesaid.

No licensee shall, subsequent to the first four years after the construction of his works, discriminate between the users of water regarding the price thereof.

If the whole amount of water agreed to be furnished by a licensee is not available, then each user shall have furnished to him so much water as shall bear to the available water the same proportion as his usual supply bears to the whole amount agreed to be furnished.

Any licensee violating these provisions shall be guilty of an offense against this act and liable to a fine not exceeding \$1,000 for each offense, or to imprisonment for not more than two months, or to both.

The minister may grant to any licensee the right to store for irrigation purposes during periods of floods or high water or during periods when water is not required for irrigation any water not being used during such periods.

Companies licensed under this act make a return to the minister on or before the last day of January in each year for the year ended the 31st day of December preceeding, such return being attested by the oath of the president and secretary of the company and showing the amount expended on construction and repairs; the amount received from shareholders; the amount of bonds issued; the amount received for water supplied for irrigation; the amount received from other sources; the amount of dividend declared and paid; the amount of capital stock authorized; the amount of capital stock subscribed; the amount of capital stock paid up to date; the amount of bonded indebtedness; the amount bonds sold for; the rate of interest bonds bear; the amount of other indebtedness and rate of interest; the cost of management; a statement of the works, their extent and character, the number of miles of canals, ditches, etc.; the number of users; the number of acres actually under irrigation; the number of acres of irrigable land in this system; the names of officers and employees; the proposed extensions during ensuing years and acreage; such other data as the governor in council sees fit to order.

A copy of the by-laws of the company, with all amendments thereto, must be attached to said return.

The returns may be waived in the case of a private person supplying water solely to himself.

No tariff of charges for water furnished by any licensee shall come into operation until it has been approved by the minister.

Any company may acquire land by purchase or lease for improvement by irrigation, and shall dispose thereof within fifteen years after its acquisition, otherwise such land shall revert to the Crown, excepting such lands as are actually under cultivation or are being used for farming, gardening, stock raising, tree planting, or forestry, provided that the lands so excepted do not comprise more than 10 per cent of the total area of land brought under irrigation by the company.

The minister may define the manner in which the measure of water shall be arrived at; define the duty of water according to locality and soil; define the portion of the year during which water shall be supplied for irrigation; regulate the extent of diversion of water; regulate from time to time the water rates which may be charged by licensees; impose penalties not exceeding a fine of \$200 or three months' imprisonment, or both, for violations of any regulation of this act; regulate the manner in which water is to be supplied, whether continuously or at stated intervals, or under both systems; make any regulations which are considered necessary to give the provisions of this act their full effect.

BRITISH COLUMBIA.

In August, 1907, the government of the province of British Columbia appointed a commission consisting of F. J. Fulton, a member of the cabinet, and Prof. L. G. Carpenter, of Fort Collins, Colo., to make an investigation of the conditions of the province as concerning irrigation and the best method of dealing therewith. The following is a summary of the report of the commission as applying to the irrigation problems of the province:

The Province is bounded east and west by high ranges of mountains, and the intermediate area with masses of lower elevation, from 4,000 to 7,000 feet, generally wooded and forming the sources of many small streams. The large rivers, such as the Fraser, Thompson, and Columbia, have cut their channels below the elevation of the surrounding country, and are therefore out of consideration for use in irrigation, which must be, with slight exceptions, supplied by the smaller streams.

The location of the land on benches above the streams in comparatively small tracts makes the construction of gravity ditches on a large scale almost out of the question on account of the excessive cost. The natural development is by irrigation from the side streams or by some system which will take the water

from the main streams and use it on a limited tract, which necessitates some system of pumping.

Undoubtedly nearly all the valleys and benches at an elevation of less than 2,000 feet may be turned into productive land of high value, if sufficient water can be applied. In general, 3 to 5 acres of watershed will be required to irrigate 1 acre of land, but the conditions are such that almost no limit can be put to the future development. The casual examination of southern British Columbia would indicate that several hundred thousand acres might reasonably be expected to be developed within a reasonable time. Moreover, the limit to irrigable land dependent upon a fixed water supply tends to increase, because it is a well-known fact that a given amount of water will serve more land after the land has been irrigated for a few years.

It is evident that British Columbia is destined to be an extensive area of irrigated land of high value, which will be subdivided into small holdings and will maintain a large population. This future development will, to a very great extent, depend upon reservoirs. The small streams heading in the low mountains are apt to become low at the period of the year when water is most needed. At other seasons there is an excess of water. In many of these cases there are splendid reservoir sites, some of which can be utilized at little cost. There are other natural lakes which touch upon privately owned land. Orchards require water late in the season when the streams are low. The storage of water becomes therefore of great importance.

In connection with reservoirs, is associated the right to use the streams to carry the water from the reservoir to the canal.

Duty of water.—For the conditions of British Columbia, no single amount would probably be better than an amount of 75 acres per cubic foot per second.

There is also destined to be much development by pumping of water from streams.

With respect to legislation concerning irrigation in the province, the most necessary changes are, first, a recognition of the right to store water in reservoirs, expropriate land for that purpose, carry water through natural streams; second, a means of adjusting the excess records already existing on streams; third, a water administration, which would develop as necessity arises. This would best be under one responsible head and under such provisions as best accords with the spirit of local institutions.

DOMINICA.

Owing to the formation of a delta at the embouchure of the Yaque del Norte River, the shallowness of the channels into which the river became subdivided rendered navigation impossible. In order to render the main channel navigable, the smaller branches were partially closed by dams, thus throwing the main body of water into the principal channel. The result of this was to deepen the bed of the main channel so as to bring the normal water level below that of the smaller branches and thus cause an area of land about 400 miles square, previously one of the most fertile spots in the island, to become barren for lack of water.

Remedial legislation with regard to this tract has been for some time under consideration, and the Government has finally decided to construct a system of irrigation canals through this district. The plan approved is an extremely simple one, consisting of raising the water into a reservoir at the point of divergence from the main channel and conducting it thence by gravity along the canals. The estimated cost is not to exceed \$500,000. The land commanded by the project is at present worth from \$2 to \$5 per acre, but will probably increase rapidly in value as soon as the government work is begun. It is remarkably fertile and especially adapted to the cultivation of cacao, sugar cane, and bananas.

CEYLON.

The regulations according to which matters relative to irrigation in Ceylon were administered were consolidated and amended in 1906 under an ordinance entitled "The Irrigation Ordinance, 1906," the main provisions of which are as follows:

Any district in the island may be proclaimed by the governor in council an irrigation district for the management of matters connected with irrigation in that district.

After the proclamation, the proprietors within the district shall meet and decide whether the ordinance shall be operated with the aid of headmen or village councils, or both; and shall appoint a committee representing the district, to be associated with the government agent for consulting with him and advising him in matters connected with irrigation in the district. The committeemen shall serve for five years.

Headmen.—The proprietors within the irrigation district may elect one or more headmen, whose duty shall be to attend to all matters connected with the irrigation and proper cultivation of the paddy fields, maintenance of rights and works, and to see that the provisions of the ordinance are properly carried out, subject to the direction of the government agent. The headman shall be reimbursed for all his expenses and may be awarded remuneration for his services either in money or in kind.

Village councils.—The village council shall consist of not less than three nor more than seven men, selected by the president of such council (who shall be the government agent or person deputed by him) from among the proprietors of irrigable lands in the district. The council shall hold inquiries into matters concerned with alleged breaches of the regulations of the irrigation ordinance of 1906, the proceedings shall be summary, and the council has the power to inflict penalties not exceeding 30 rupees (\$10).

In case it is proposed to construct a new irrigation work, or to repair, improve, or extend an existing work, the government agent may call a meeting of proprietors to decide what action should best be taken, and whether government aid is necessary.

The probable cost of the proposed work having been estimated and government aid not being deemed necessary, the majority^a of the proprietors shall determine the rate of contribution toward the work payable by each proprietor either in money or in kind in respect of each unit of measurement of his land; and the government agent shall prepare a similar specification showing the contribution charged against each land and payable by the owner thereof.

If the majority of the proprietors determine that government aid is necessary the government agent shall record the rate of contribution which the proprietors are willing to make toward the work, shall make out a report setting forth the irrigable area of the district, the names of the proprietors and probable aggregate returns, and submit the application of the proprietors with this report and his recommendation to the governor.

If the governor sees fit to approve of the application he will, if necessary, cause a survey of the land to be prepared, and shall cause a plan and estimate of the proposed work to be made; and he shall further decide whether the contributions offered by the proprietors are sufficient, and if not, refer the proposal back to the government agent for adjustment.

The contributions payable by a proprietor may be either: (1) A rate per acre per annum in perpetuity, to provide for the cost of construction and of maintenance, or (2) a lump sum per acre, payable in a fixed number of annual installments, and the cost of maintenance, payable by means of an annual rate; or (3) a share of the whole cost of the work, proportionate to the area of the proprietor's land found capable of irrigation, payable in 10 equal annual installments, and the cost of maintenance, payable by means of an annual rate.

The governor shall have the power to cause the specification of the irrigable lands to be from time to time altered and enlarged as additional lands may be found irrigable.

^a "Majority of proprietors" means a majority consisting of two-thirds at least of the proprietors present, provided such majority represents at least one-third of the irrigable acreage; if not, then the votes of the proprietors representing two-thirds of the irrigable acreage shall constitute the majority.

Crown lands capable of being irrigated may be sold, subject to a yearly rate per acre in perpetuity on the lands so sold, as their share of the cost of the works and their maintenance.

Proprietors are allowed, subject to the approval of the governor in council, to convert their contributions into a rate per acre per annum in perpetuity if they desire to do so.

The rate for maintenance shall be assessed by the government agent. In making this assessment the agent shall be guided by the report of the director of irrigation, giving the estimate of the probable cost of annual maintenance for such work and in the case of any work which has been maintained for more than five years by the actual cost of maintenance of such work for the preceding five years. The rate shall be reassessed by the government agent at the end of every period of five years.

FORMOSA.

The chief products of the island of Formosa are rice, sugar, and tea, and as all these require a sufficient amount of water at regular periods in order to give the best results the irrigation problem is one of considerable importance. Scientific storage of the rainfall on an extensive scale forms one of the plans of the Japanese for the development of the resources of the island, and a bureau of irrigation, a subdivision of the department of public works, has lately been established.

There are in Formosa about 375,000 acres under cultivation in rice alone. One-half of this, roughly speaking, is irrigated by a system of canals and earthen reservoirs constructed during the Chinese occupation. The Japanese irrigation bureau proposes to provide irrigation for the rest of the rice fields and at the same time protect the district against damage from inundations during the rainy season.

Before the advent of the Japanese the Formosa sugar-cane growers believed that the sugar cane required no moisture except that provided by the rainfall. Since then, however, the native canes have been generally abandoned in favor of the superior Hawaiian and Javanese plants, and it is discovered that to get the best results from these irrigation of some sort is necessary. There are about 90,000 acres planted in cane, and the irrigation bureau has included this area in its proposed irrigation system.

Besides the lands already planted in rice and sugar cane there are large districts which at present, owing to the danger of inundation and from similar causes, are hitherto uncultivated; it is proposed to include these lands also in the irrigation belt, thus bringing the acreage of the irrigable district to about 1,000,000 acres.

The estimated duty of water is 50 acres per cusec for rice, and 100 acres per cusec for sugar cane.

No official information has as yet been published concerning the projects of the bureau of irrigation, but it is stated that these will necessitate an expenditure of about \$15,000,000. The system will consist of more than 60 canals, several of which will be lined with masonry or concrete. The reservoirs supplying the canals will have masonry and concrete dams. Wooden flumes and conduits will be but little used. The flood and sluice gates will be of iron. Pumps for lifting water will be installed in certain localities. In the south of the island, where fuel is extremely scarce, the water power will be used to generate about 10,000 horsepower of electricity.

INDIA.

GENERAL STATEMENT.

The irrigation works of India may be divided into three main classes—canals, tanks, wells. Under canals are classed works of any considerable size for diverting the waters of streams and distributing them over the land; under tanks all works for the storage of water and all natural depressions the water of which is used for irrigation; and under wells are comprised works providing access to the subterranean water supply.

In the case of large tanks and canals, works are required which it is beyond the means of individuals or village communities to construct, maintain, or operate, and these are therefore constructed by the Government, the necessary investigations being made by the public works department. All irrigation works may therefore be further classified as “public works” and “private works.”

Although the statistics published by the irrigation branch show that more than half of the irrigated area in India is irrigated from private sources, yet during the last thirty-five years all irrigation projects of any importance have been planned, constructed, and maintained by the Government. These public works never pass out of government control. The Government assumes all risks, receives whatever profits may accrue, and has complete control over all public sources of water supply.

Public works consist of two main classes—those of which the capital outlay has been provided out of revenue, which are called “minor works,” and those the capital for which has been raised as a government loan, which are called “major works.” Both are included under the head of “productive works.” There is also a third class of works classed as “protective,” for the reason that they are included in the works designed to protect the districts subject to drought from crop failure or famine. (Railways built with this object are also classed as protective works.) The funds for the construction of these protective works are supplied from the annual appropriation made for the famine fund.

Major productive works are provincial—that is, included in the budget of the province—in Bengal and the United Provinces; in all other parts of India they are imperial. All protective works are imperial. Minor works are provincial in Bengal, the United Provinces, Madras, and Burma; in all other provinces they are imperial. The Punjab provincial works have been constructed in recent years out of provincial revenues, and the Godak Canal in the Bombay Presidency is classed as imperial.

With respect to public works in general, the government of India has power to sanction their construction up to a maximum limit of \$335,000, exclusive of charges for establishment. Local governments sanction up to the same limit works which are chargeable to provincial funds, but in respect of imperial works their powers of sanction are limited as follows:

Government of Bombay	\$67,000
Government of Madras	65,000
Other provincial governments	17,000
Local administrations	7,000

These general powers of sanction may of course, with respect to irrigation projects, be applied to minor works only.

Regarding the funding of irrigation projects, these may be classed as follows: (1) Major productive works, carried out from funds borrowed by the Imperial Government, the return being got by water rates on the area irrigated; (2) minor canal and navigation works, the capital outlay of which is provided out of the imperial or provincial revenues, the return being got as in the case of major works; (3) protective irrigation works, for which the capital outlay is provided out of the Indian famine fund. The returns are got in the same way as in the former cases, but protective works are not expected to be directly financially remunerative.

In Bengal, where there is a fixed land-revenue assessment, the funds for construction are usually advanced at moderate rates of interest, ranging from $3\frac{1}{4}$ to 5 per cent, the principal being repayable in periods of from fifteen to thirty years. Where there is no fixed system of land revenue, the Government in some cases carries out improvement works free of charge, in order to avoid remissions of land tax, or a rate may be authorized to cover interest charges.

Irrigation works in general are planned and constructed by the irrigation branch of the public works department as above explained. In a few cases collectors of districts have projected irrigation works and caused the same to be constructed out of district funds, in which case the works have remained in charge of the district.

Works constructed wholly or partly by the Government are managed and controlled by the Government in perpetuity.

Throughout India the basis for charges for water supplied by government works for irrigation is the area irrigated; but different systems of charging are in operation in different parts of the country. In Bengal, the United Provinces, the greater part of the Punjab, and on all the newer works in Bombay (excluding Sind), a water rate, varying with the kind of crop grown, is charged per acre watered, apart from the land-revenue assessment. This is known as the occupier's rate; it is paid by him in return for the water supplied and forms part of his expenses of cultivation. It is for many reasons impossible to fix this rate so high as to leave the occupier no larger margin of profit than would suffice to induce him to take water, and therefore the introduction of irrigation is generally accompanied by an enhancement of rents.

In the provinces whose revenue is not fixed a share of this increased rent is taken by the Government at the periods of revision either in the ordinary way or by the imposition of an owner's rate, which, although payable by the owner, is, like the occupier's rate, levied on the area actually irrigated during the year.

In provinces such as Bengal, where the land tax is fixed, it is not permitted to increase it on account of the advantages accruing from the construction of new irrigation works; and as the occupier pays the water rate the owner reaps all the benefit of levying an increased rental, without bearing any of the burden thrown on the taxpayer by the construction of the works.

In Sind, where there is but little cultivated land that is not irrigated, the charges for water do not take the form of an occupier's rate, but are included in the land-revenue assessment. In this prov-

ince the land revenue is fluctuating, and is levied only on the lands actually cultivated during the year.

Nine-tenths of the assessments on irrigated lands are regarded as due to the works, and are credited to them in the accounts of the province as irrigation revenue. It is therefore practically a water rate, varying with the area actually irrigated and the crop sown, although taken in the form of land revenue.

In Madras separate water rates are charged on dry lands watered by newly constructed works or extensions before the area of irrigation has become established, and in a few other special cases. But in general the irrigation charge is consolidated in the land-revenue assessment.

In Bombay, also, on the older works of the presidency proper the charge is consolidated. The settlement officer in Madras and Bombay takes into account all the circumstances of each survey field, the productiveness of the soil, its proximity to market, etc., and he may fix his assessment as high as \$4.50 or as low as \$0.81 per acre on fields which have enjoyed the same amount of irrigation.

There is one defect common to all those systems, in that no inducement is offered to the cultivator to economize water and to see that it is not wasted between the government channel and the field.

As far as irrigation and drainage works are concerned, the Government as a general rule supplies all the funds, takes all the risks, and receives all the revenue. In the case of guaranteed railways the Government shares expenditure, profit, and loss with the companies, an entirely different system from that of irrigation.

The deltaic embankments on the Irrawaddy in Burma are cases in which the Government executes and maintains the works and receives all the revenue.

The drainage works on the Sirhind and Bari Doab canals, Punjab, are cases in which the Government bears all costs and receives no direct return.

The Magrahat drainage project in the Pergunna district, Bengal, is a case in which the Government advances funds on certain interest and repayment terms.

The Government does not grant concessions for land reclamation by private parties by irrigation or drainage for the simple reason that it is not politic to leave the cultivators at the mercy of middlemen from whom they would receive less liberal terms than from the Government.

In the case of the great irrigation colonies in the Punjab, the Government, when introducing irrigation, allotted the waste lands in small areas free of charge to peasant cultivators, and to capitalists and others in much larger areas on payment of certain prices, and each class has to pay the land revenue and water rates. The peasants are required to remain in the village in which their grant is located.

PRIVATE IRRIGATION WORKS.

As already stated, more than half of the irrigated area in India is in the hands of private individuals, and there are vast tracts of country which, were it not for private irrigation, could not be protected against the effects of drought.

Private works consist of canals, tanks, wells, and "other sources," under which term are included chiefly small channels for taking out water from rivers and streams; these last are frequently provided with weirs of an inexpensive and temporary character. In the only instances in which works of any size have been constructed by private companies they have proved conspicuous failures. Individual owners are seldom able to provide the capital or skilled direction required for such large works.

In order to stimulate and assist private irrigation improvements, advances are made by the Government to the land-owning and land-cultivating classes. This system is known as "takhavi" and has existed in India from time immemorial, and is now regulated by special laws, namely, the land improvement loans act and the agriculturists' act for the whole of India, and by rules under these acts framed for each province by the local governments and sanctioned by the government of India.

Under the former act, money is advanced for specific purposes and under the latter for seed, cattle, and other miscellaneous agricultural requirements.

The rate of interest charged for these loans is $6\frac{1}{4}$ per cent for all classes of improvements except in Madras and Bombay, where the charge has been reduced to 5 per cent. The Imperial Government advances the money for these loans to the provincial government at 4 per cent.

When a loan is desired by the Indian farmer for improvements upon his land, application is made to the local collector.^a The applicant is required to state exactly what he proposes to do with the money and to show that it will be productive and to specify the sum he purposes to lay out upon the work from his own resources. The security offered must be either that of the land or a tenant right, though in some cases personal security is accepted.

If after a thorough examination of the property the collector is satisfied of its necessity and desirability, the loan is made.

"Improvements" are defined to include "any work which adds to the letting value of land," and it is to be noted that in the indication of these the first place is given to "wells, tanks, and other works for the storage supply and distribution of water." Then comes "the preparation of land for irrigation," and next its "drainage, reclamation, protection from floods or erosion;" and then is placed the renewal or reconstruction of the foregoing; and, in conclusion, the word is made to embrace all other works which the local governments, with the sanction of the governor in council, may declare therein included.

The period of repayments is fixed by the collector of the district, except in Madras, where the period for wells is fixed at 30 years; in no province may this official fix a period longer than 20 years, while in Bengal his discretion is limited to 10, and in the central provinces and United Provinces to 15 years. In the Punjab the fixing of a period longer than 20 years requires the sanction of the government of India, and is only granted in exceptional circum-

^a Collector: This is the title of the executive officer at the head of each district in India, the districts forming the units of administration. He has entire control of the district and is responsible to the lieutenant-governor of the province.

stances. The farmer may borrow from the Government up to 75 per cent of the value of his land in order to carry out agricultural improvements thereon.

From the report of the irrigation branch of the public works department for 1905-6 the following information is taken:

During the last 50 years—that is, since 1858, when the present form of government for India was established—the area irrigated by the government has increased from a little over 3,500,000 acres to 22,998,435 acres in 1906. This area comprises 15,162,440 acres irrigated by major works, returning a gross revenue of \$16,440,442, and 7,835,995 acres irrigated by minor works, returning a gross revenue of \$7,079,599. The irrigation works paid 7.04 per cent in 1905-6 on their capital outlay. Thirteen of the major works yielded a return of 1.53 per cent only, but this was more than counterbalanced by the revenues from the other 28 works. The highest returns were obtained from the following canals:

	Per cent.
Western Jumna Canal.....	Net revenue.. 9.62
Upper Bari Boab Canal.....	Net revenue.. 11.29
Lower Chenab Canal.....	Net revenue.. 20.79
Eastern Jumna Canal.....	Net revenue.. 18.53
Ganges Canal.....	Net revenue.. 7.99
Cauvery Delta.....	Net revenue.. 24.82
Godāvāri Delta.....	Net revenue.. 19.75

The most important irrigation works in India are:

The Ganges Canal, which was completed in 1854 and has cost \$10,828,752. It comprises 520 miles of main canal and 2,945 miles of distributaries. During the year 1905-6 it supplied water to 1,369,393 acres. The Sirhind canal in the Punjab, which has cost \$12,948,975 and consists of 538 miles of main canal and 4,606 miles of distributaries. In Madras the Godāvāri, Kistna, and Cauvery systems, which irrigate together 2,568,131 acres.

At the irrigation conference held in Simla in 1904 it was officially stated that the area under government irrigation in the year 1902-3 was 19,801,273 acres, representing an annual increase of about 347,000 acres since the year 1869, when the present system of irrigation administration was established. During the three following years 3,065,730 acres have been added to the government area, representing an annual increase of over 1,000,000 acres.

The published returns of the department of revenue and agriculture for 1905-6 show that the net area of India, exclusive of feudatory and tributary states, but inclusive of Upper and Lower Burma and Assam, was 557,236,906 acres. Of this total area 207,683,741 acres were under cultivation and yielding crops. The area of government irrigation was nearly 23,000,000 acres; that under private irrigation is estimated at over 26,000,000 acres; so that we have in India a total acreage of about 50,000,000 acres under irrigation, or very nearly one-fourth of the entire cultivated area of the Indian Empire.

BHANDARDARA PROJECT.

The secretary of state for India has sanctioned an estimate of \$2,805,000, the anticipated cost of the Pravara River protective irrigation work in the Ahmednagar district of the Bombay presidency. This will be the second of the great ghat-fed irrigation works designed to protect the wide Deccan tracts where drought is such a frequent infliction. The first project in the general scheme of protection against drought and famine has already been commenced; this is known as the Dama project and will tap the headwaters of

the Godávari River, and include large storage works at the top of the Western Ghats in the neighborhood of Lanovla, and two long canals, which will serve 240,000 acres, chiefly in the Nasick district, and cost \$2,855,000.

For the project now sanctioned water is to be taken out of the Pravara, a tributary of the Godávari. This great construction work will provide for a reservoir at Bhandardara, where a masonry dam 250 feet high will be built in a remarkable gorge of hard rock, and a storage of 8,800,000,000 cubic feet of water (202,020 acre-feet) obtained. The catchment area from which the water will be derived is only 47 square miles in extent, but it is the area of the heaviest rainfall of the Ghats. The impounded water will be distributed by canals 34 and 44 miles long, utilizing works now serving the Ojhar canals and embankments thrown up during the last famine. The total area commanded is 228,720 acres, of which 182,976 are cultivable.

It is anticipated that this scheme will, when in full working order, return a little less than 4 per cent upon the capital outlay. Consequently, although not classed among the productive works, it is one of the most promising of its class in the Bombay presidency. The government intends to take up gradually the whole chain of works, which extends as far south as those chronic famine areas, Sholapur and Bhizapur. When this is completed famine in its acute form will be impossible in the Deccan.

NATIVE METHOD OF IRRIGATION.

Any notice concerning irrigation in India would be very incomplete that did not take into some account those ancient methods of applying water to the soil which have persisted from the earliest periods of artificial irrigation in all arid and tropical countries where it has been practised, and are at this day in use in India over an area even greater than that which is served by the government works themselves. These ancient operations are, as far as the individual farmer is concerned, so many different methods of lifting water from a well, a canal, or a tank, and applying it to the little plot of ground from which he expects to obtain sustenance for himself and his family. Of these methods the commonest is the well.

WELL IRRIGATION.

This method consists simply in sinking a well to the depth required, and rigging at the top two standards of logs from 4 to 6 feet high, with a crossbeam, to which are fastened two pulleys. Over these pulleys are rigged ropes attached to a leather bag that will hold about 30 gallons of water. This bag has two openings, one much larger than the other, the larger one being intended to receive the water and the other, which forms the end of the tail of the bag, to discharge it. One of the ropes is fastened to each end of the bag. The bag is lowered into the well, and when filled with water is pulled up by a span of bullocks, the ropes being attached to the center of the yoke. The top of the well is 8 to 10 feet above the level of the surrounding land, so that the bullocks pull down hill. When the bag reaches the top of the well a man stationed there secures it with a rude con-

trivance and loosens the tail rope so that the water runs into a sluice which conducts to the irrigating ditch. Water thus obtained is sometimes carried three-quarters of a mile, the distance depending largely upon the incline of the land.

The wells vary considerably both in depth and in diameter. Water is sometimes found in abundance 20 feet below the surface, but not infrequently it is necessary to go down 400 feet. Sometimes the supply depends on seepage, and again veins of water with a strong and unceasing flow are struck. The native method of sinking a well is interesting. When the hole is about 6 feet deep a basket lining made of strong, pliable limbs of trees from 12 to 18 inches in thickness is sunk to the depth of the excavation. Resting on the top of this lining is built a circular tube of sandstone. This tube, which is to form the masonry lining of the well, is frequently as much as 40 feet in height and is smoothly finished inside and out. As the excavation of the well proceeds the weight of the masonry forces the wooden lining lower and lower, and this process continues until water in sufficient supply is reached. The masonry tube is then, if necessary, added to until it attains the height above ground required for the incline for the oxen and the settling as the wooden foundation rots and gives way, the excavated earth forming the inclined path along which the bullocks walk while operating the water lift.

Very little money is spent on such a well. There are many hands in the village willing to do such work. Men and women alike excavate the well, quarry, shape, and haul the stone and cut the timber. If any iron work is needed a few rupees will purchase the material, and it is shaped for use at the village smithy. Thus the well is constructed and prepared for operating without the expenditure of any money worth mentioning. It has been suggested that American windmills should find a ready market among the Indian ryots, but the small amount of money that would be needed for the erection of such a windmill would be quite beyond the financial ability of the village community, and moreover the average Indian cultivator possesses so little comprehension of modern machinery that both pump and windmill would soon be hopelessly out of order.

Among other methods of lifting water in use among the Indian peasantry may be mentioned the Persian wheel, which corresponds to the sakiyeh of the Egyptian Delta, and is an endless band of leathern buckets operating round a couple of wheels or drums, the lower of which is partially sunk below the level of the water in the canal or tank. As the buckets pass over the top of the upper wheel they empty their contents into a trough, which conveys the water to the sluice or ditch.

In India may also be seen a contrivance closely resembling the Egyptian shaduf, wherein the leathern bag or bucket is attached to the thin end of a long pole balanced between two uprights. This is operated usually by one man, who dips the bag into the water and then swings the pole sharply round and tilts the water into the receptacle that is to convey it to the field; also the basket scoop, operated by two men, and very similar to the Egyptian natali; the doon or oscillating trough and other devices of a rude sort, but adapted to the nature and customs of the native races, and all of them doubtless of great antiquity.

EXTRACT FROM THE REPORT OF THE IRRIGATION BRANCH OF THE PUBLIC WORKS DEPARTMENT OF THE UNITED PROVINCES FOR 1905-6.

The following particulars from the report will be found of interest as exhibiting the operations and status of the government system of irrigation in an Indian province:

The total capital outlay during the year amounted to \$1,058,300, of which \$658,300 were expended on protective works, \$325,600 on major productive works, and \$74,400 on minor works. This was 35 per cent more than in the previous year.

During the year 156 miles of new channels were constructed, thus bringing the total of all channels up to 13,709 miles.

The gross receipts of the year amounted to nearly \$3,000,000, or \$500,000 less than in the previous year, the falling off being due to the poor assessment of the rabi^a crop of the previous year, which was collected during the year under report.

Working expenses amounted to \$1,185,000, and the net profit, after deducting the interest charges for the year (nearly \$560,000), amounted to approximately \$625,000. The percentage of return on total capital outlay varied from 18.53 per cent for the Eastern Jumna Canal to 0.72 per cent for the Fatehpur Branch of the Lower Ganges Canal. The Upper Ganges Canal (oldest and largest in the province) returned 7.95 per cent; the Agra Canal returned 2.02 per cent. The returns from the only protective canal in the province earning revenue showed a loss of about \$47,000 on the year's working. The net revenue for the year fell below the amount guaranteed to the provincial government by the Government of India by about \$172,000.

The area irrigated, 3,523,439 acres, was the largest ever recorded in the province, the extraordinary demand for water being due to the failure of the monsoon and early winter rains.

STATISTICS.

The following extract from the statement of the canals and reservoirs for the year is of interest. The Ganges Canal and Agra Canal are selected for quotation:

Statistics of Ganges and Agra canals.

	Ganges Canal.	Agra Canal.
Source of supply of water.....	Ganges.	Jumna and Hindan.
Minimum discharge of river ever recorded..... cusecs..	4,427	132
Minimum discharge during the year..... do....	4,661	273
Maximum discharge of canal..... do....	8,073	1,656
Normal annual rainfall..... inches..	29.6	20.5
Area irrigable by complete project..... acres..	1,212,600	356,500
Area irrigable at present..... do....	1,282,500	376,000
Gross area commanded..... do....	4,466,700	975,200
Culturable area..... do....	3,363,200	921,900

^a The crops grown in India, exclusive of sugar cane, which is in a class by itself, are included for statistical and other purposes in two classes, kharif and rabi. Under "kharif" are included rice, maize, millet, and also indigo and cotton; under "rabi" come the food grains, such as wheat, barley, gram, peas, and also the poppy. The irrigation season for kharif crops is from April to September; for rabi crops, from October to March. This double-crop system, which prevails throughout irrigated India, is largely accountable for the high returns from many of the irrigated districts.

Statistics of Jhānsi Lakes Reservoir and Hamipur Lakes Reservoir, 1905-6.

	Jhānsi.	Hamipur.
Source of supply of water.....	Rainfall.	Rainfall.
Catchment area.....square miles..	24.5	45
Normal annual rainfall.....inches..	28.4	49
Contents of tank between levels of surface of full supply and sill of canal-head sluices.....million cubic feet..	743	927
Area of surface at full supply.....acres..	2,593	3,593
Gross area commanded.....do....	5,700	4,000
Culturable area.....do....	4,500	3,000
Area irrigable by complete project.....do....	4,500	2,900
Area irrigable at present.....do....	2,500	3,300

Total expenditure on both tanks, 82,398 rupees (\$27,466).

The comparative statement of irrigation and rainfall for 1904-5 furnishes the following statistics:

Irrigated area.

	Acres.
Total area of the civil district of the united provinces.....	28,445,717
Culturable area.....	7,693,967
Cultivated area.....	16,709,210
Culturable area commanded by the irrigation works.....	10,499,500
Area actually irrigable by said works.....	3,907,500
Area actually irrigated by said works.....	3,523,439

Rainfall.

	1904-5.	1905-6.
	<i>Inches.</i>	<i>Inches.</i>
Upper Ganges Canal.....	37.88	22.78
Agra Canal.....	24.23	13.59
Upper Ganges Canal.....	39.11	9.48
Dūn canals.....	90.09	50.35
Betwa Canal (protective):		
In Jhānsi.....	38.50	9.50
In Hamirpur.....	37.70	16.30
In Jalaun.....	40.11	8.78

Extract from the statement of occupiers' rates in force for the year 1905-6.

	Per acre irrigated.	
	Ganges Canal.	Agra Canal.
I. Sugar cane, per year.....	\$3.33	\$2.22
II. Orchards and gardens, per half year.....	1.33	1.33
Tobacco, poppy, all rabi crops except linseed and peas, per crop.....	1.33	1.33
III. Linseed, peas, all kharif crops except those noted in II, per crop.....	.66	.66

The value of the crops raised during the year by the aid of canal water was 13½ crores of rupees, or about \$44,166,000.

EXTRACT FROM THE ADMINISTRATION REPORT OF THE IRRIGATION BRANCH OF THE UNITED PROVINCES FOR THE YEAR 1906-7.

Expenditure.—The capital expenditure amounted to nearly 38 lakhs (about \$1,254,000), of which the protective works in Bundelkhand absorbed about 25½ lakhs (\$840,000), works on major canals nearly 11 lakhs (\$363,000), and minor works 1½ lakhs (about \$50,000).

Mileage of channels.—The total length of channels now in operation is 13,927 miles, an increase of 218 miles as compared with the previous year. In addition, 196 miles of the Ken Canal (protective) were completed during the year, but were not open for irrigation when the report was issued.

Area irrigated.—The area of irrigation fell to 2,588,457 acres, the rainfall during the monsoon being sufficient for sowing over a large part of the district and good winter rains completed the season. The value of crops raised by canal water was estimated at 10,40,45,144 rupees (\$34,681,710), being an average of \$13.4 per acre irrigated.

Revenue.—Protective works. The result of the year's working presented a profit of 1,48,544 rupees (\$49,510), which represents a profit of 2.44 per cent on the capital outlay, which is by far the best result yet obtained, the operations of previous years having resulted in loss. After deducting the interest on the capital, the deficit for the year is only 39,758 rupees (\$13,252).

Productive works.—These brought in a gross revenue of nearly 120 lakhs (\$4,000,000), the highest figure on record, being an increase of over 42 per cent upon the figures for the previous year. After deductions, the net revenue represented a return of over 9½ per cent on the capital outlay.

Protective and famine works.—There are four protective works in the United Provinces, the Betwa Canal, in operation; the Dhukwan Weir, under construction; the Ken Canal, just completed, and the Dhassan Canal, under construction.

The capital outlay on these works has been 1,01,90,249 rupees (\$3,396,749) up to date. The average percentage of net revenue to capital has been 1.46.

Famine relief and insurance.—The expense of construction work carried out under this head has been met from different funds, imperial and provincial, the imperial contribution up to the end of 1907 having been: Ordinary, 2,04,350 rupees; famine relief and insurance, 58,55,261 rupees; and the provincial, 32,974 rupees, making a total of 60,90,585 rupees, or \$2,030,198.

The Betwa Canal commands a gross area of 1,155,000 acres, with a culturable area of 982,400 acres; the mileage of channels as sanctioned in the original project is 597; of these all but 1 mile of a distributary channel were completed and in operation at the end of the year 1906-7. The other works are still under construction, with the exception of the Ken Canal, which only opened in 1907 and has not yet been reported upon.

Under this head the following extract from a report by the consul-general at Calcutta, under date March 26, 1908, is noteworthy. He writes, *inter alia*:

"Irrigation in its various forms saves India from being a channel house in this year of grace 1908. But for irrigation * * * the horrors of the situation in India this year could not be adequately told. As it is, the people are keeping together, are able to live by economy, and to feed their stock. * * * The Government is supplementing the efforts of the people to live by direct relief, by test and public works; that is, by creating work on railroads, telegraph lines, canal repairs, and many other ways. It may be truthfully said that the millions in India were never in as good condition to fight off famine as now. There will be suffering and starvation in remote parts, but on the whole the British-India Government and the people are to be congratulated on the results of the vast endeavor to ward off famine."

RECLAMATION OF WASTE LAND THROUGH IRRIGATION.

During the last twenty years the Indian government has sanctioned the construction of several irrigation projects, the intention of which is to redeem by irrigation large areas of waste land and plant colonists upon the areas thus rendered available for cultivation. The general results of these schemes have been favorable, and large extensions of the system are under consideration. There are millions of acres in India at present unproductive, but commanded by water

courses whose flow is only partially utilized; and it is the design of the imperial government to ultimately bring all of these areas under cultivation. It is expected that this plan, if carried out, will largely reduce the congestion in some of the famine districts.

The largest of these colonization systems at present in operation is the Chenab system, by which a large area of waste land, commanded by the Chenab, has been settled by thriving colonies. The government built good roads through the settlements and connected the center of the system—the new town of Lyallpur, named after a former lieutenant-governor of the Punjab—by rail with the main line of railway. All the settlements in this system are thriving.

The waters of the Jhelum have been utilized in a similar manner, and the results of this scheme are equally satisfactory. In western Punjab a vast project, commanding over 2,000,000 acres, is being carried out along the same lines; and yet another contemplates the utilization of the waters of the Sutlej to irrigate the lands on its left bank. The success of the projects already in operation is some warrant for expecting similar results from those as yet under construction.

JAVA.

The social and political system whereby Java was administered since the year 1832, which is called the "culture system," was based in principle upon the officially directed labor of the natives. This "culture system" depending for its successful operation upon government ownership of land, the soil of Java was claimed as government property, and all work carried out in connection with land improvement or reclamation in general was consequently government work. In the western part of the island a considerable acreage has passed, during the last twenty years, into foreign, chiefly European, ownership, the increase being from 1,000,000 acres in 1890 to over 10,000,000 acres at the present day, and the Government has also during that period relaxed in some measure the severity of the laws governing native labor; the compulsory one day in seven formerly exacted from all natives being now remitted in return for a yearly poll tax of 1 guilder; and a law passed in 1870, which afforded opportunity to private energy for obtaining waste lands on hereditary lease, emphyteutic tenure has given considerable impetus to private agriculture. The extent of this impetus may be gauged from the following figures: In 1890 the area of the government land was about 22,000,000 acres, and that on emphyteusis or other form of tenure about one-half that amount; in 1905 the government area amounted to 17,000,000 acres, while the emphyteutic and leased lands approached 50,000,000 acres; in addition to which there were nearly 10,000,000 acres of private lands under cultivation on the western side of the island.

In consequence of this "culture system," which, though no longer enforced in the letter, survives in the spirit, all irrigation or drainage work is in the hands of the government and is administered by the department of public works. No subsidy or concession of any kind in respect of irrigation enterprises is made to any individuals or corporations.

All irrigation and drainage works in Java are planned, constructed, and maintained by the Government. If the actual construction work

is not undertaken by the public works department, it is let out on contract and executed under the supervision and control of the government engineers. The recommendation of a local municipal board to the public works department is the initial step toward obtaining government assistance with regard to the irrigation of any district. The capital outlay is not, as a rule, recoverable, but in some cases a direct return is secured through charges made for the use of the water supplied. In general, however, the returns are secured through an occupier's or cultivator's rental, such charges being scaled according to the value of the crop raised, and assessed as a land tax. The government lands thus provided with water are leased to private individuals according to a system of allotment which limits the area assignable to each applicant in proportion to his financial standing, some farmers thus obtaining large areas, others much less; there is, however, no law limiting the amount of land which one person may acquire in this manner, nor is there any law applying to the domicile of the applicant; but the Government does not grant leases to private corporations.

Examples of the service which irrigation and drainage work may perform in protecting property against damage from inundation can be found within the limits of the three principal cities of Java—Batavia, Samarang, and Soerabaya. These are traversed by a network of canals, which relieve the rivers in the rainy season and reduce the danger of inundation to a minimum.

The latest official report available gives the area under irrigation on December 31, 1904, as 7,188,140 acres. But little additional area has been included since that date, the work of the department in respect of irrigation and drainage having been chiefly confined to the maintenance and operation of the works already in operation.

SIAM.

The Siamese Government has recently established an irrigation branch of the department of public works, for the purpose of bringing under direct and more efficient control various irrigation districts in the country, more especially in the southern region; but this branch of the service is still in a formative state, and no official details as to its operation or plans are yet obtainable.

In the hill region in the north some irrigation systems limited in extent and of an antiquated type still exist. As these deteriorate and their restoration or repair becomes necessary, the requisite funds are raised by the farmers in the district whose interests are affected by the works; the construction or repair work is carried out under the supervision of the headman of the nearest village, and the National Government is not in any way concerned in the matter.

In the plains of lower Siam are numerous canals, constructed primarily as navigable waterways, but also in many cases serving as protective conduits against overflow and inundation. These have been lately placed in the charge of the newly established irrigation department.

For a considerable number of years landholders along the banks of these government canals have made a practice of constructing dis-

tributary canals for their own use, the water being taken out of the government canals. The sole object of these operations has been the enhancement of the value of the riparian holdings, and the Government has lent no financial or other aid to the projects.

The only important work carried out of late years has been the construction and operation of the Bangsit Canal and its distributaries, a concession having been obtained from the Government permitting the construction of an irrigation system in a district consisting chiefly of waste or uncultivated land and covering about 600,000 acres. In consideration of the construction of the canals and the rest of the system, the company, whose interest in the project is limited under the concession to twenty-five years, acquired a free grant of a mile strip of land on both sides of the canal and its distributaries.

Radiating from the main canal are numerous smaller ones, usually about 2 miles apart at the places of origin. The total length of these distributaries is about 500 miles, and they serve about 435,000 acres of what was formerly a barren district but is now under cultivation in rice.

The main Bangsit Canal has a bottom width of about 30 feet, that of the laterals is about 16½ feet, the slope in both cases being 45 degrees. After the land acquired by the company in consideration of constructing the canal had been disposed of, its diligence in respect of the maintenance of the system slackened considerably, and the negligence therein displayed has been the cause of numerous disputes between the company and the Government, arising out of complaints on the part of persons who have purchased land from the irrigation company. The main canal, which also serves as the navigable channel of the district, is kept in fairly good condition, and the tolls received at the locks from the different vessels that pass through are a source of great revenue to the company, whose enterprise has altogether been more than ordinarily financially successful, immense sums having been realized from the sale of the lands bordering on their canals.

This concession of land in return for construction work is the nearest approach yet made by the Siamese government toward fostering the reclamation of the waste lands of the country, but the question of extending government aid to private parties desirous of ameliorating the soil conditions by means of irrigation, drainage, or otherwise has lately been occupying the attention of the authorities, and probably will be dealt with before long by the irrigation branch of the public works department.

VICTORIA, AUSTRALIA.

Under the provisions of the water act, 1905, which superseded all previous enactments defining the participation of the government in the reclamation of land by means of the storage and distribution of water, all state works of water supply in Victoria are constructed by the board of land and works, and these are upon completion vested in the state rivers and water supply commission which, according to the aforesaid act, has, in addition to other powers and duties, the control and management of the works, irrigation, and water supply districts, and the property of the waterworks trust.

Of the works existing prior to the passing of the act of 1905, as well as of those thereafter to be constructed, some are declared to be free head works, in respect of which no charge is made either for interest or maintenance on the districts supplied therefrom. As regards all other works, the proportion of interest, maintenance, etc., properly debitable to each district is recoverable by means of rates which the commission has the power of levying upon the owners or occupiers of the land benefited thereby.

The commission is required, out of funds legally available, to carry out surveys to ascertain the water supply and storage resources of the state, and to determine the means and cost of developing such resources and of improving and extending works for the conveyance and distribution of water, and to determine the areas capable of being profitably supplied with water.

Leases of crown lands may be granted as sites for the erection of pumping machinery, and licenses may be issued to any persons or corporation to divert water from any river, creek, stream, etc., or to conserve or supply water, to supply water power, or for any other purpose. The minimum rent charge for any pump site is £2 (\$9.70) per annum. The charge for a license to divert, etc., water is usually based on the benefit to be derived therefrom by the licensee.

The governor in council, by advice of the minister of water supply, may create new irrigation districts, and these, after creation, are vested in the commission.

The department of Victorian water supply, the responsible head being the chief engineer of water supply, plans and constructs all state works of water supply for the board of land and works.

There is no law in Victoria limiting the aid which the Government may extend to municipalities, districts, or corporations with respect to irrigation or land reclamation in general, but in practice government participation takes one of two forms: Either (1) a money grant—this for the financial year ending June 30, 1907, was \$364,987—which is divided among the shires and boroughs entitled to share in the appropriation upon a classification basis proportional in every case to the local rate levy; or (2) a special grant, either to aid in the opening up or development of a new district or in improving communications in sparsely settled localities, or in assisting repairs to municipal works which have suffered damage from unpreventable causes, such as fire, flood, etc. These grants are invariably free and nonrecoverable, but are frequently made subject to conditions binding the municipality interested to contribute some portion of the cost of the works.

The planning and the direction of the execution of the works is in the hands of the municipalities concerned, subject to the approval of the municipal proposals and designs by the department of public works and commission of water supply. There are no particular conditions to which such proposals and designs must conform; municipal engineers must, under the Victorian local government act, possess certificates of competency, and so long as the proposals and designs are in agreement with correct engineering principles and reasonable considerations of economy, of which the department above referred to is the judge, alterations are very rarely requested.

LAND RECLAMATION.

The reclamation of swamp or morass land in the State of Victoria may be said to be conducted entirely on national as distinguished from municipal lines. In such works as the reclamation of Koo-wee-rup Swamp, 54,000 acres; Condah Swamp, 9,000 acres; and Noe Swamp, 11,000 acres, besides many others of less importance, it may be pointed out that these areas were crown morass lands which the Government thought it advisable to prepare for settlement purposes. The works were therefore carried out by the public works department with national funds, which are still being gradually refunded by sale of the government land at enhanced prices as well as indirectly by the increased settlement of the districts. On free head works such as the above, the State had expended up to June 30, 1906, about \$5,650,000; on other state works, excluding the waterworks districts and the waterworks trust, but including most of the state contribution to municipal irrigation and water supply enterprises, the sum of (about) \$1,200,000 had been expended.

There are no instances of municipalities having carried out reclamation work with government assistance; nor has any government concession ever been granted for the purpose of reclaiming lands by drainage; this is undertaken as a state work, and the cost of the same is as far as possible recouped by the sale of the land reclaimed. No conditions as to domicile attach to the sale of government lands under these terms.

RECLAMATION BY IRRIGATION.

The report of the rivers and water supply commission furnishes the following statement as to the land under irrigated culture in the year 1905-6: Area irrigated from state works, 130,451 acres; area irrigated from private works, 86,482 acres; total area irrigated, 216,933 acres.

The entire area of the districts was 2,702,180 acres, exclusive of roads and reserves; the area irrigated in 1905-6 was therefore very nearly 10 per cent of that of the districts.

The state rivers and water supply commission only came into existence in 1906, and the reclamation work of the state was previously under the control and management of the secretary for water supply. From the report for the year 1904 the following particulars relative to some of the government irrigation projects are extracted:

Loddon national works.—A regulating reservoir on the Loddon River, designed to regulate the flow of the river and increase its effective volume by storage against times of insufficient natural supply. The dam in the river bed is an overshot weir of concrete, with a crest line of automatic flood gates (Chaubart type); from the weir to the left bank runs an earthen embankment, riprapped on the rear slope, and protected on the face by concrete pitching in the upper part and broken stone beaching in the lower. The length of the masonry weir is 320 feet, that of the earthen extension 700 feet. Four cast-iron pipes of 36 inches diameter built into the body of the weir, and controlled by valves worked by a gearing above flood level, provide outlets for the water. The dam impounds 610,000,000 cubic feet (about 14,000 acre-feet). The total cost was \$680,000, inclusive of land compensation.

Kow Swamp national works.—An intake and regulator were constructed at the effluence of Gunbower Creek from the Murray River, and a cut made from the creek to a natural lagoon, known as Kow Swamp, converting the latter into a reservoir capable of storing 780,000,000 of cubic feet of water for summer use. The reservoir is tapped at its northwestern point and connected by a short branch with the Macorna Channel (leading from the Murray to the Loddon River), which thus gets its supply from the Murray in winter and from the Kow Swamp storage in summer. The channel crosses the Loddon by a wrought-iron siphon of 6 feet diameter and there terminates. The total distance from the Gunbower intake to the Loddon Crossing is 42 miles. The supply capable of being delivered is equal to 166 cusecs during the winter and 105 cusecs during the summer months. The purpose of the works is to furnish a supply of water for stock, domestic, and irrigation purposes to the lower Loddon district. The total cost to date, including land compensation, is \$873,000.

Lake Lonsdale reservoir.—This reservoir is formed by a dam $1\frac{1}{2}$ miles in length, constructed across the Little Wimmera River and the low ground adjacent, at its outlet from the lake. On the left bank the dam is of earth, with a core wall of clay, extending 7,695 feet from the slopes of Mount Dryden to the river. The river channel is crossed by a rubble concrete masonry weir 310 feet long. A waste weir 325 feet in length has been excavated on the rocky spur of Mount Drummond, on the right bank of the river. The capacity at F.S.L. is 1,981,000,000 cubic feet (45,477 acre-feet). The total cost of this reservoir, including land compensation, was estimated not to exceed \$250,000. (The report of the commission for the year 1906 gives the cost of this project at \$235,300.)

The Mildura trust.^a—In the year 1887 a concession was given for a special area of 250,000 acres on the Murray River at Mildura. This was thrown open to public tender and secured by the only applicants, Messrs. Chaffey Brothers. The conditions required the expenditure of £300,000 (\$1,455,000) in twenty years on irrigation works, fruit growing, drying, preserving, and canning industries; £10,000 (\$48,500) to be laid out during the first year, £35,000 (\$169,750) during the first five years, and £140,000 (\$679,000) during the second five years. On the settlement of 100 families the holders of the concession were to establish a college for instruction in irrigation, fruit growing, drying, preserving, etc. A license to occupy the land for the currency of twenty years was issued on these conditions; the freehold of the land to be given on an expenditure on improvements of an amount varying from £2 (\$9.70) to £5 (\$24.25) per acre.

On this basis the licensees secured a total freehold of about 30,000 acres which they were permitted to dispose of in limited areas only, together with a sufficient water right to each parcel sold. The maximum area which could be sold to any one person for fruit growing was 80 acres, and for other produce 160 acres.

Although a large amount was expended the Mildura settlement did not prosper, and Chaffey Brothers' interest was subsequently transferred to a limited liability company which ultimately went into liquidation.

The state government had to come to the assistance of the settlers, and Mildura has since become a prosperous and self-supporting settlement. This is the only instance of granting a concession.

At the present time amending legislation is under consideration with the object of providing for the establishment of homestead irrigation settlements along the River Murray, the state government erecting the pumping plant, constructing channels, and making the cost thereof a capital charge on the land. It is proposed to provide for making these allotments (a) independent holdings,

^a Extract from the statement of the surveyor-general of the crown lands department.

or, alternately (b), to attach to the homestead block by title a larger area of more or less remote land for dry farming, and in this case the two parcels of land are to be inseparable. The object of this is to render it possible to utilize for dry farming land on which it is not considered safe to place homes, the latter being established on the river frontage.

NEW SOUTH WALES.

Reclamation work in New South Wales is handled as one of the divisions of the public works department, coming under service head of public watering places, artesian bores, water conservation, and water supplies and drainage.

The expenditure under this head for the year 1907 was £22,075 or \$107,065 approximately. Of this amount about \$30,000 was spent on maintenance and repairs, \$20,000 on surveys, \$25,000 on minor works, about \$8,000 on the Wentworth irrigation area, and the greater part of the balance upon artesian bores.

Work was begun on the Murrumbidgee irrigation scheme, and the Cataract dam was completed.

Little progress was made in swamp drainage (which is operated under the water and drainage act of 1906, providing for loans from the state treasury for draining swamps and malarial lands), partly owing to the wet weather and also to the want of surveyors to make the surveys and draw up designs and estimates as required by the act. Applications for drainage under the act to the amount of nearly 170,000 acres are at present pending; about 10,000 acres have been already drained. In some instances the petitions have been defeated by the action of interested parties who were opposed to the scheme.

Artesian bores.—The whole of the bores sunk under the artesian-wells act have been assessed, the total assessment amounting to about \$5,800 per annum. All assessments are paid up to date.

During the year 5 bores were completed and handed over to the trustees; 12 bore trust proposals, covering an area of 1,485 square miles, were notified; and 14 bore trusts, covering an area of 1,503 square miles, to be watered by 519 miles of distributing drains, at a gazetted cost of \$200,000 approximately, were constituted.

In December, 1906, an amending water and drainage act was passed, giving extended powers to the minister and trustees; also for the control of the artesian waters, providing that no bores, other than government, shall be sunk, enlarged, or deepened without a license, and for the control of supply when obtained. This was found necessary to protect the interests of persons who had sunk bores by preventing the indiscriminate sinking of future bores. The amending act gives the minister power to construct channels or embankments without easements or resumption. It also provides for the right of entry by minister or trustees for the purpose of construction, maintenance, or repair. The running of lines of levels in connection with the isopotential lines is being carried on with all expedition in the artesian districts, and will throw much light on the question of the source of supply of the waters feeding the artesian beds. The geological survey carried on for the purpose of defining the intake areas of the artesian water-bearing beds is being steadily advanced. A plan of the artesian water-bearing basin, with the isopotential lines marked as hitherto traced, is appended to the report.

Wentworth irrigation area.—The Wentworth irrigation scheme had its inception shortly after Chaffey Brothers settled at Mildura, Victoria.^a The original project failed for lack of funds. The Government then took it over, it being felt that, having such a magnificent and permanent water supply as that furnished by the Murray River, and the soil being uniformly suitable for irrigation, some effort should be made to establish an irrigation colony on the New South Wales side of the river.

The irrigation area comprises 10,000 acres of land situated in the angle between the Darling and Murray rivers. Over 1,000 acres, fronting the river Murray, have been dealt with and subdivided into blocks of from 5 to 34 acres. During the early history of the community very little progress was made, but in March, 1906, the minister of public works inspected the settlement and in consequence special terms encouraging settlers to set out orchards and permanently improve their holdings were made. In granting leases no rent is charged until the water is flowing past the block. The lands were classified and an annual rent determined. The first year only one-fifth of the rental is required, the yearly payment increasing every year until for the fifth year the full rental is payable. On these terms 700 acres have been leased and are under cultivation.

The leases are granted for a term not exceeding thirty years, at the expiration of which the Government may renew the lease for a further term not exceeding thirty years. The leases include a water right entitling the holder to an equivalent of 30 inches of water per annum, but not more than 4 inches in any month.

There are now 53 holdings in the settlement and the prospects of the settlers are satisfactory. The area under vines and fruit trees is about one-third of the total holdings and is steadily increasing.

From the report of the Murray River commission of 1904 the following is extracted with respect to the Wentworth trust:

The Wentworth irrigation trust is also largely a failure, only 130 acres out of an original grant of 10,000 being in cultivation. The land occupied by this trust area is strongly saline and otherwise unsuitable.

This was in 1904. It will be seen that conditions at Wentworth have since then considerably improved. With respect to the saline constituents, the report of 1907 says:

It was thought that there would be trouble in regard to seepage and salt, and the whole area has been carefully watched, with the result that no indication of the rising of salt has been obtained, although water has been running in the main channel for seven years.

The Wentworth settlement may now be regarded as a successful experiment in irrigational agriculture.

The Murrumbidgee irrigation scheme.—After an exhaustive inquiry lasting nearly ten months, the standing committee on public works recommended the carrying out of the proposed Murrumbidgee irrigation scheme as recommended by the department of public works at an estimated construction cost of £1,574,008 (\$7,649,675). The following is a brief description of the scheme:

1. A high masonry dam across the Murrumbidgee River at the Barren Jack site, about 22 miles from the town of Yass. This dam,

^a A brief account of the Mildura colony is given in the report upon land reclamation in Victoria.

designed to hold up a depth of 200 feet of water, will back up the Murrumbidgee for 40 miles and have a capacity of 766,324 acre-feet.

2. A movable diversion weir on the Murrumbidgee River, about 236 miles below the Barren Jack dam, to feed the main canal.

3. A main canal taking off above the weir, about 132 miles long.

4. A main branch canal about 35 miles long and a number of distributing canals.

The amount of high-class irrigable land commanded by this canal is estimated at about 357,000 acres. Nearly half of this area is freehold. It is proposed to acquire the most suitable of these lands and divide them into small holdings up to 100 acres in area, and sell them to settlers on easy terms. The irrigation rate proposed will be \$1.25 per acre-foot, amounting to \$3.75 per annum for 30 inches of water.

The supply of water being insufficient for the whole area commanded, holdings of dry land, to be worked in conjunction with the irrigated holdings, will be available. The area included in this portion of the scheme will be about 1,000,000 acres, which will be supplied with water for stock purposes and for the irrigation of 1 acre out of every 30 for fodder crops.

As soon as parliamentary sanction was obtained for the scheme preliminary operations were commenced, and already considerable headway has been made. A township has been established, water supply provided, and sanitary system installed. A light railway has been laid out connecting the works with the main line of railroad, and surveys for the diversion works and canals are in hand.

Irrigation at Hay.—An irrigation scheme was started several years ago at Hay, a town on the Murrumbidgee, under the authority of an act of Parliament, but at the time of the holding of the Murray River commission the enterprise could not be regarded as successful. Some of the land at Hay was not suitable for irrigation and the site as a whole was not so favorable as at Mildura. On this head the evidence given before the commission by the mayor of Hay (who was also a member of the irrigation trust) is of general interest. Replying to a question as to soil and general conditions at Hay, the witness replied as follows:

I consider the soil as adapted to irrigation and I have confidence in the scheme if only we had practical men on the area—men who understand fruit culture and the growing of crops by applying water to the land. Unfortunately we have all had to learn from experience. We have found that land and water in themselves are not sufficient; that there is a proper method of putting the water on, and that method has to be learned by experience. A good many people, who put in crops regardless of method, found that they get no result.

Perhaps the most successful irrigation in New South Wales is that which is carried on by private landowners. One of these has 60 miles of channels on his property, the water being supplied by pumping.

SOUTH AUSTRALIA.

The largest irrigation settlement in South Australia is Renmark, on the right bank of the Lower Murray, and about 15 miles below Mildura in Victoria. This settlement was started by Chaffey Brothers, the originators of the Mildura settlement, in 1887, and on the same plan as Mildura, the license granted by the South Australian

government for the Renmark settlement being identical with that granted by the Victorian government in the case of Mildura. For reasons similar to those operating at Mildura—chief among these being the inexperience of both promoters and settlers in respect of irrigation—the Renmark scheme was a failure and the works were taken over by the South Australian government, an irrigation trust being formed to control and operate the works and area commanded. The area of the trust is 12,000 acres, of which in 1902, 3,000 were in irrigated cultivation, supporting a population of about 1,000, with 200 irrigation holdings, an average of 15 acres per holder. The rainfall at Renmark is about 6 inches. In 1900 a loan of £16,000 (\$75,750) was made to the trust by the South Australian government for the purpose of improving the irrigation works and channels, nearly all of which have been lined, thus reducing evaporation in passage very considerably.

Renmark is a pumping station; two reservoirs are filled by two 20-inch centrifugal pumps each, and from these the water is distributed through the channels by two other centrifugals. A water right charge of £1 (\$4.86) per acre per annum is made to cover the cost of raising and distributing the water; this is found to be more than sufficient. Five or six irrigations of about 5 inches each, are given, the average total being 28 inches. Concerning this supply, the report of the Murray River commission, 1902, states:

This represents a volume so great as to inspire apprehensions of serious waste. If this volume really is required for fruit culture in the climate and soil of the Murray Valley, no time should be lost in amending the grants to the trusts; while the fact should be borne in mind in any future concessions proposed under like circumstances.

In 1894 the government of South Australia set apart several areas on the banks of the Murray for the establishment of village settlements. Several methods of providing for the unemployed had been tried, with little result. The establishment of these settlements was regarded as an experiment; they were started on communistic principles, but, owing to the lack of practical knowledge and disagreements among the settlers, they have been by no means successful. The original number of the settlements was eleven. Three of these have been entirely abandoned; of the remainder, embracing an original area of over 40,000 acres, less than 2,000 were being cultivated in 1902. It is stated, however, that the residuary settlers are making a fair living.

THE INTERSTATE COMMISSION ON THE RIVER MURRAY, AUSTRALIA, 1902.

The Murray River is the great natural line of drainage of south-eastern Australia, the basin of the river and its tributaries comprising 414,253 square miles, an area one-third larger than that of the 13 original States of the Union. It is the greatest waterway of the commonwealth, and the subject of the utilization of its waters is one of vast importance to the inhabitants of the three States—New South Wales, Victoria, and South Australia—through which it flows. The political position of the river, which forms for the greater part of its course the boundary between two States, and passes through a third

to discharge its waters into the ocean, has from time to time raised questions of interstate rights which were not of easy adjustment; and the inevitable rivalry of the three main utilities to which the river is servient, irrigation, navigation, and water supply, was for long a fertile source of difference and dispute which none of the States was capable of settling single handed.

In the year 1884 a royal commission was appointed in New South Wales for the purpose of inquiring, among other matters, into the best method of conserving and utilizing the rainfall and other sources of water supply; and the utilization of the waters of the River Murray formed a prominent feature of the report of the commission. The recommendation of the committee was, in brief, that a joint trust, equally representative of New South Wales and Victoria, be constituted, and that this trust should have complete control of the whole of the waters of the Murray River from its source to the boundary of South Australia. The waters of the river and of its tributaries within these limits were to be the common property of the above-named colonies, to be diverted and used by them as directed by the trust.

The colony of South Australia, through which the Murray passes on its way to the ocean, being greatly interested in the navigation of the river, asked to be joined in conference with the other two colonies. Circumstances prevented any conference from taking place, and since then the establishment of the Renmark irrigation trust and a number of smaller irrigation settlements have given South Australia an added interest in the maintenance of the volume of water in the river.

The chief tangible result of the commission was the organization in New South Wales of a water conservation service (Victoria had for several years a water supply department) and the institution of several irrigation projects. In Victoria an added impetus was given to irrigation, and several schemes were carried into effect.

The birth of the Australian commonwealth brought into existence a new authority vested with powers which, within certain limits, are supreme. The introduction of this new and to some extent controlling factor made it more than ever necessary that the States interested in the disposal of the waters of the Murray basin should come to some conclusion as to their respective rights and interests in the river and in works for the utilization of its waters. Several successive years of drought stimulated public feeling and anxiety concerning the matter, and in March, 1902, the Murray River Canal League invited the federal premier, together with the premiers of New South Wales, Victoria, and South Australia to a conference upon the subject. The resolutions passed at the conference were, in brief, as follows:

I. That the governments of the commonwealth and of the States concerned be urged to cooperate in a comprehensive scheme for the utilization of the waters of the Murray, which, while improving the navigability of that river, will also provide for the needs of the residents on both banks in the conservation and distribution of its waters.

II. That the States of New South Wales, Victoria, and South Australia be asked to empower the Federal Government to provide national storage reservoirs on the Upper Murray.

IV. That, in the opinion of this conference, the circumstances of Australia demand that all natural waters not already appropriated under legal sanction shall be declared public water and made subject to a suitable system of law applicable to the whole of the continent.

Before the conference separated it was announced that a royal commission would be appointed by the three States to investigate and report. Three commissioners, representing the States of New South Wales, Victoria, and South Australia, were appointed in May, and after holding 63 meetings in various parts of the commonwealth for the purpose of taking evidence, besides 80 meetings in committee, rendered their report in December of the same year.

The most important chapters of this report, from the standpoint of another nationality, are those which occupy themselves with the following questions: I. The interests connected with navigation and their claims as compared with those of general supply and irrigation; II, the legal aspect of state rights and the apportionment of waters; III, the division of available water among States; IV, the control of the river and its tributaries. It has been deemed advisable to give at some length the substance of these chapters.

NAVIGATION, GENERAL WATER SUPPLY, AND IRRIGATION.

The navigation of the Murray has always been principally in the hands of South Australia. In most years the river is navigable up to Wentworth (about 15 miles below Mildura) for about seven months in the year; the Darling being generally navigable from Blanchetown to Albury for an average of six months in the year. The settlers along the banks of both rivers are dependent on water-carriage for their supplies and for the transit of their products, the cost of land-carriage being prohibitive. About 90 registered steamers and the same number of barges ply upon the river.

It seemed unlikely that the navigability of the river had been appreciably affected by what had already been done in the way of irrigation, the total of the water diverted for that purpose, both in New South Wales and Victoria, having had no sensible influence upon the duration of the period of navigation. The important factor affecting this has been the natural storage in certain lakes; a great part of which flowed out as the river sank, thus maintaining its volume at times for one or two months beyond the period at which navigation would otherwise have ceased.

Witnesses generally were of opinion that it would be a convenience to have the river open for navigation all the year round, but the volume of evidence showed that the periods of actual navigability were sufficient both for the volume of trade and the needs of the settlers. An important exception was however the case of the Renmark irrigation settlement (a South Australian Irrigation Trust below Mildura, with an irrigated area of about 12,000 acres), where the settlers suffer considerable annual loss owing to the river being closed at the time their perishable fruits are ripe.

It was not easy to arrive at the value of the trade maintained by navigation, but it was stated in evidence that for several years from 1878 the South Australian government had paid to that of New South Wales £40,000 (\$194,000) per annum for the privilege of free trade with the latter colony. In considering the question whether the volume of river-borne trade would be sufficient to warrant the expenditure of about £350,000 (nearly \$1,700,000) in the construction of locks and weirs, the great diminution in the volume of river trade during the last few years was felt to be important. Although several

witnesses ascribed this in the main, if not entirely, to the shortage of water in the river, the balance of evidence seemed to point to the conclusion that the falling off was chiefly due to the drought of the three preceding years, and also to the recent railway extension and to the preferential treatment given to the railroads.

As regards the comparative importance of the navigation and irrigation interests, it was shown that an irrigable area of 50,042,000 acres existed in the three States, consisting chiefly of alluvial plains, and that the whole of these, unless provided with a water supply sufficient to create fertility, must remain uninhabited wastes. Large portions of this irrigable district were shown to be commanded by the Murray and its tributaries, and capable of being irrigated by them. In New South Wales the government surveyors estimated the area capable of being irrigated, should the proposed schemes be carried out, at nearly 2,000,000 acres; the Water Supply Department of Victoria gives 2,000,000 acres as a conservative estimate of the land that can be profitably irrigated; and the irrigable area in South Australia was given at 2,500,000 acres.

The weight of evidence on the whole was in favor of considering irrigation as superior in importance to navigation, and the decision of the commission was:

The conclusion is unavoidable that, although existing vested interests demand certain substantial concessions in favor of maintaining the navigable condition of the rivers, the extension of navigation, except by the construction of locks, is not to be looked for. It is further evident that, in the event of circumstances at any time causing a conflict of interests, the demands of navigation must yield to those of general supply to settlers and for the irrigation of land.

LEGAL ASPECT OF STATE RIGHTS AND PRINCIPLES TO BE ADOPTED IN APPORTIONMENT OF WATERS.

It was agreed that in considering the just allotment of the waters of the Murray basin to the use of each of the three States, the legal grounds of their several claims could not be entirely ignored. But the uncertainty of the effect of decisions—common law alone being applicable—rendered it impossible, even were it advisable, to deal with them on this sole basis. Considerations of policy, of vested interests, and of the general welfare of the people must be accorded due weight in the settlement. It would be a public calamity if state rights should be left to be fought out in the courts; it would be hardly less calamitous to attempt to deal with them on strictly legal grounds, untempered by other considerations.

The diversity of opinion as to these rights, arising among trained lawyers, as shown by the legal opinions given in evidence, rendered the task of the commission still more delicate and difficult.

With regard to the question of superior state right in the waters of the Murray, the majority of the witnesses held that, subject to certain minor differences, the sole jurisdiction over the river and the exclusive right to legislate in regard to it, are vested in New South Wales. The basis for this opinion appears to have chiefly been a clause in an imperial act, which runs as follows:

The whole water course of the River Murray from its source herein described to the eastern boundary of the colony of South Australia is and shall be within the territory of New South Wales.

As against this absolute view, however, it was admitted that both the State of Victoria and her citizens, as riparian owners, were entitled to an easement, almost tantamount to a right of property, in the water of the river; the distinction between a right of property and a right of government being clearly maintained.

As to the tributaries of the Murray, witnesses agreed that the rights of the States within their own boundaries have not been affected by federation, except that they have been restricted in respect of diversion, when this would impede the navigation of the main river. The balance of opinion was that, before federation, each colony had full control over and power to use all the waters within its own territory, irrespective of the effect such use might have on the waters of the Murray itself. It was even held by some that the only limit to the right of New South Wales to the absolute use of the waters within her territory, including the Murray down to the South Australian boundary, arose out of the obligations of comity toward the neighboring States. Following this doctrine, Victoria would be within her powers in granting rights of diversion from the tributaries; she would exceed them in granting rights in the main stream. The opposite view was put forward in a claim on behalf of South Australia, that she is entitled to a share in the waters of the Murray and of all the tributaries of that river. This appears equivalent to a declaration that riparian rights of States are subject to the ordinary rules of common law affecting private proprietors. On this point great divergence of legal opinion was manifested; one view being that riparian common law was applicable between States as between individuals; another, that riparian law, as between States, would be the same as between individuals, with the qualification that the state rights are territorial, the private rights pertinent to property; a third view, the converse of the first, was that the common law of riparian right, as between private proprietors, does not hold as between States.

With respect to the precedence of the respective claims of navigation and of irrigation, the opinions given in evidence may be summarized thus:

Legislation in regard to diversions must have respect to the maintenance of navigation.

Any interference with the natural flow of the Murray that would render the river less navigable would be unconstitutional. In this sense the tributaries are part of the main stream.

Any scheme interfering with the natural flow of the river, and constituting a complete or even serious obstruction to its navigability for the purposes of interstate trade, would be an infringement of the constitution, subject, however, to the restrictions imposed by section 100 (State rights of reasonable use).

The establishment of federation does not affect the constitutionality of any State bringing about a diminution of the navigability of the Murray, save to the extent to which such enactment conflicts with some enactment of the federal legislature on the subject of navigation.

Water for irrigation may be held to be a natural right where cultivation is impossible without it. This application of common-law principles has grown up in America; it leads to the conclusion that the use of water for navigation must be subservient to irrigation. If the English common law were admitted here, without modification, five-sixths of the Australian continent would remain uninhabitable for all time. Both in America and in Australia, with the increase of population, irrigation will eventually become a factor in the life struggle of humanity.

Natural rights of navigation extend only to tidal rivers. In nontidal rivers they may be acquired by lengthened use, but extend only so far as that use.

America has amended the common law to meet local conditions. In that country the common law doctrine as to navigability of rivers has been set aside, and it has been held that a river navigable in fact is navigable in law. But though navigability in fact gives rise to a legal right, that right is not paramount, and does not give navigation precedence over irrigation. Under the federal constitution the test of navigability of a river would consist in its capacity for being used as a channel of trade and commerce.

A definition of the term "reasonable use" was given as: "Such use as will not interfere with the rights of others."

On the question of jurisdiction it was clear that prior to federation the enforcement of riparian rights as between colonies or between the citizens of different colonies was practically impossible, by reason of the absence of any common interstate law of riparian rights and of any tribunal with power to declare and enforce them. Questions of riparian rights between citizens of different States were, prior to federation, within the jurisdiction of the courts of that State where an alleged wrong was done. These have now passed to the federal high court, which may declare the law as between States and as between citizens of different States; it can not make or amend the law.

There was a consensus of opinion as to the need for amendment of the common law in regard to riparian rights. The leading views are summarized as follows:

Under the Roman civil law the water of streams is of public right, and its appropriation by a first comer gives him a right as against lower riparian owners. The civil law is more conducive to the use of water in agriculture than the common law and would be more beneficially applicable in Australia. In arid America the common law has been in some States abolished, in some ignored, in all modified to meet the actual facts.

It is a matter for legislation, which is the quickest mode of dealing with it, to declare a code of law with regard to the use of waters.

The common law might be abrogated in respect of riparian rights in so far that these would be vested in the crown instead of in private owners.

Whatever action may be taken, the vested interests already existing, whether of navigation, irrigation, or general supply, must receive due recognition. The conservation of existing interests such as have grown out of the natural conditions of the country and have remained for a long time unchallenged, is a fundamental principle of law, and it was determined by the commission that provision should be made for the continuance of the navigation of the river to an extent at least equal to heretofore, and that the construction of weirs and locks be recommended.

After provision for navigation there would remain a considerable but variable surplus available for irrigation and other industrial uses, the equitable apportionment of rights in which was the most difficult part of the duty assigned to the commission. The decision of the commission was, in brief, to consider the country commanded by the river water—that is, the country that can be served by gravitation, either from the main river or from the tributaries—as a whole, and then to endeavor to solve the question:

How and on what principle are rights to be assigned, so as to insure widest extent of permanent settlement, the maximum of productiveness, the most active internal trade, and the most profitable foreign commerce?

From this point of view, the largest rights should be assigned to the States that have the largest areas of irrigable land; whose land,

commanded by the available water supply, is of the character and quality most likely to prove profitable when irrigated; and whose land, of suitable quality, can most readily and cheaply be provided with the necessary works of conveyance and distribution.

Some regard must also be had to vested interests that have already grown up, as at Mildura and Renmark, and in respect of rights conceded to certain of the Victorian irrigation trusts.

Further, there must be recognition of and concession to what would be the riparian rights of the States, if they were private proprietors, or if the common law of riparian rights could be held applicable in their case.

The natural wants of the numerous towns and villages scattered throughout the Murray basin, and of the numerous herds of cattle and flocks of sheep pasturing on the lands drained by the river and its tributaries, must be granted on a liberal scale and made a first charge on the available water supply. In recognition of this concession, there must be an end of river pollution, whether by the insanitary condition of towns or the dwellings of settlers or by the continued appropriation of the water courses of the country as common drains for the disposal of mine débris or of the waste products of factories.

Finally, in the consideration of claims and apportionment of rights the river and its tributaries must be looked upon as one.

DIVISION OF AVAILABLE WATER AMONG THE STATES.

The majority resolutions of the commission were in the main as follows:

I. Until the initiation of a system of locks and weirs in the lower part of the river and of the main tributaries, the total diversions of the upper riparian States shall be restricted to 440,000 cubic feet per minute from July to January and 370,000 cubic feet per minute from February to June. Of this allotment New South Wales is to receive two-thirds and Victoria one-third. To meet the requirements of South Australia, the amount of water sent down the river channel at the boundary line shall be, from July to January, 170,000 cubic feet per minute; from February to June, 70,000 cubic feet per minute. It is estimated that this discharge, together with the accretions within the boundary of South Australia, will be sufficient to maintain the river traffic in its present condition until the lock system is inaugurated. Should the volume of water in the river be insufficient to provide for these diversions and appropriation, a proportionate reduction shall be made in each, so as to bring their sum within the total available. In the event of a storage reservoir being constructed on the Upper Murray, the expense of the same, and the water supply derivable therefrom, to be divided equally between the three States.

From this report the commissioner for South Australia dissented on grounds generally traceable to his conviction, as stated in his minority report, that:

The first and paramount duty of the commission is to determine the minimum flow necessary to be maintained for the purpose of navigation, the question of the just allotment of the waters between the States for conservation and irrigation being subsidiary to the main necessity of keeping the rivers navigable.

CONTROL OF THE RIVER AND ITS TRIBUTARIES.

The control of navigation being in the Commonwealth, and that of irrigation and conservation in the States, it is necessary that their administration should be kept apart; whilst, however, commonwealth

authority and control of state rights should be distinct, it is important that there should be proper concert between them.

This object would be secured by the appointment of a permanent commission, representative of the three States, to administer and control diversion and to construct and control those works of irrigation and conservation in which more States than one are concerned, with powers to consult with the Federal Government and to conclude agreements with it on all such matters affecting the rivers as are subject to commonwealth jurisdiction. The powers and duties of this commission should be wide enough to enable it to deal with such questions as those remitted to this commission. Its functions should be defined with regard to the broad lines to be followed, but not with regard to details or procedure.

Matters specifically remitted to it should be:

(a) The investigation of all proposals for the construction of storage and other works intended to serve the interests of more than one State, and the apportionment of the cost thereof.

(b) The variation, when necessary to meet altered conditions or to conform with the fuller information from time to time available, of the volumes to be provided for navigation, or for the respective service of the several States.

(c) The settlement of disputes arising between the States out of matters connected with the administration of the agreement relating to the control and diversion of water from the Murray and its tributaries.

(d) The making of regulations, either temporary or permanent, limiting the volumes to be diverted from time to time or at any specified season, or diminishing or suspending diversions.

(e) Providing against the pollution of rivers and streams.

NEW ZEALAND.

Operations connected with land reclamation in New Zealand, whether by drainage or irrigation, are in general under the control of the local county councils. As far as the Dominion government is concerned, the general rule is that when works of that character require to be carried out, the local council in whose county the proposed operations are situated furnishes particulars of the necessary work, and of the estimated cost involved. Should the matter be one that appears essential to the well-being of the district, and especially where crown lands are affected, and the funds at the disposal of the local body concerned (either by way of special loan or ordinary rates and levies) are insufficient for the purpose, it has been the practice in many instances to give the services of a government engineer or surveyor to draw up a practicable scheme and specifications for carrying out the requisite work, and to aid by means of a parliamentary grant or subsidy, the prosecution of the work by the local body, subject to the supervision of a government officer, who sees to its being carried out in the most effective manner.

It is very rare that the government undertakes such a work wholly at its own expense, and that is almost solely when the lands affected are in the hands of the Crown. In such a case, the department of lands, or the department of roads, assumes direction of operations and carries out the work.

As will be seen by a perusal of the various statutes, it is customary to raise a special loan to effect the works, and all the lands within this special loan area are rated to provide for the annual interest and sinking fund on the money so advanced.

By the provisions of the water-supply act of 1891, which is still in force, all the necessary powers required for the formation of water-supply districts (locally styled "water-race districts," a "water race" being defined as "the land occupied by any natural or artificial channel for the supply of water to be used in, upon, or through any land, and all branch races taken or made through any lands for the purpose aforesaid, and includes any alteration or extension thereof, and all flood banks, dams, sluices, meters, reservoirs, or other waterworks, and all buildings and machinery, pipes, and other materials upon the land and within the limits of a water race") are conferred upon the county councils, which may, subject to the provisions of the act, purchase, acquire, or expropriate the land required for the purpose of constructing a water race, and then proceed to construct the same. Certain provisions of the act are noteworthy:

I. Before interfering with any stream or river, or diverting water therefrom, plans of the proposed alteration or derivation shall be deposited at the county court-house for public inspection, and thirty days' notice given for the lodging of objections, after which period, if no objection has been lodged in writing at the court-house or some public office, the work may proceed. If an objection is lodged, the county council meet and hear the evidence in support thereof, and either support the objection, annulling the project, or altering it as requested, or reject the objection, in which latter event appeal may be made by the objector either to the district or to the supreme court.

II. In case the council shall at any time cease for a period of two years to use any land over which it has acquired rights as a water race, such land shall (subject to any special agreement made in respect thereof with the owner or owners), upon the expiration of two years, revert to the then owner or owners of the land from which the same was originally severed; but the council shall not be liable to such owner or owners for so ceasing to use the land.

III. The council shall not be responsible for the failure of any water supply, from whatever cause the same may arise.

IV. *Special loans.*—The council may (a) raise from time to time a special loan for the purpose of exercising the powers conferred by the act with respect to water races, provided that the aggregate of all such loans shall not exceed one-half of the fee simple of the land as appearing on the valuation roll of the district. The proposal to raise a loan must be laid before the taxpayers of the district, and the consent of not less than half of the total number of taxpayers representing not less than three-fifths of the ratable property in the district obtained thereto; (b) impose and levy a special rate on all lands in the district to secure and pay the interest upon and provide a fund for the repayment of any such loan. Such special rate may be levied either (1) on a uniform scale, or (2) on a graduated scale, according to the classification of lands as described in the following section. All lands in any district which by their altitude, configuration, or other physical causes are excluded from deriving any possible benefit from a water race, shall be exempted from all rates to be levied in respect of such water race, as also all lands which are supplied with water from springs, streams, or private water races thereon, unless the respective owners consent to the lands being rated.

V. *Classification of lands.*—The council may from time to time classify all lands in the district into the following classes: (1) Lands receiving or supposed to receive immediate and direct benefit; (2) lands receiving or supposed to receive less direct benefit; (3) lands receiving only an indirect benefit from the construction of a water race; (4) all other lands; and the rates shall be levied upon the first three classes of lands in such proportion as the council may in each case appoint. Any person who thinks himself aggrieved by such classification may appeal against the same on the grounds following, and no other: (a) That the classification does not fairly classify the lands of the appellant; (b) that any land liable to be classified is omitted from the classification or is not fairly classified.

The notice of appeal must be given to the clerk of the nearest magistrate's court, and the case heard before him; and the decision of the magistrate, whether to support the classification or to amend it as petitioned, shall be final and conclusive.

VI. Charges for water supply.—The council may prescribe the terms and conditions upon which any water race made by it may be used, and upon which water may be supplied, and the rates for the same, and may provide, if advisable, for a scale of charges differing in any district from those in another. Such charges may be estimated to cover the interest and sinking fund on any loan raised for the purpose of construction, maintenance, and repair of water races. Every occupier and owner of land in, through, over, under, upon, or along which a water race has been constructed shall be liable to pay the afore-said charges, unless exempt as already noted. But no occupier shall be liable for charges in arrear for any period exceeding two years from the time when such charges first became due.

If the council shall constitute districts in which different scales of charges shall be imposed for the supply of water from water races, the water-supply charges raised in that district may be wholly expended upon the races in that district.

VII. By-laws.—The council may from time to time make, alter, and repeal by-laws (1) to prevent the obstruction of water races; (2) to prevent the pollution of water in races; (3) to prevent the driving of animals or vehicles, or the conveying of machinery or other material through or across water races, except at the appointed crossings; (4) to punish persons for interfering with any works or appliances connected with water races without the consent of the council; (5) to protect rangers and other persons employed by the council in connection with water races in the discharge of their duties; (6) to prevent the widening, deepening, or alteration of the course of water races without the consent of the council; (7) to prevent generally trespasses, nuisances, and obstructions to water races, and make provision for the proper protection and management of the same; (8) to provide for the cleansing, repair, and maintenance of any water race by the owner or occupier of land on which such race is situate.

VIII. The council is moreover authorized (1) to prevent the diversion of any stream, or portion thereof, within or bounding a water-race district, without the consent of the council; (2) to remove or cause to be removed any channel, intake, weir, or other works which cause any such river or stream to be diverted, and generally to do or permit to be done anything necessary for the efficient use by the council of the whole of the waters in any river or stream.

IX. The governor may from time to time make, amend, or revoke regulations under this act to provide that any lessee of pastoral land held under any land act may construct water races to irrigate the land so leased, and may agree that on the expiry of such lease the outgoing tenant shall be entitled to valuation for the benefit which any such races are to the land comprised in the lease. (Amendment of 1894.)

X. The council may (1) stop the flow of water in any water race for the purpose of cleansing, repairing, altering, enlarging, or extending any water race or reservoir for water, or for any other purpose which the council may deem proper; (2) stop, reduce, or alternate the flow of water in any water race, and control and manage all water races in the county in such manner as may be deemed best adapted for the purpose of providing a supply of water. (Amendment of 1898.)

XI. It shall be the duty of the council constructing or maintaining a water race to prevent low-lying lands being thereby flooded, water-logged, or otherwise seriously affected. Any person owning or occupying land which he has reason to believe will be injuriously affected by the construction of any water race may apply to the district or supreme court for an injunction to prevent such water race being proceeded with unless adequate provision is made to prevent such land being flooded, water-logged, or otherwise injuriously affected, and the court may thereupon grant such injunction or make such order as shall best meet the circumstances of the case.

XII. A county council may by special order appoint not less than 5 nor more than 7 ratepayers who shall have the management on behalf of the council, and may confer upon such managing ratepayers all or any of the powers of management possessed by the council, provided that no such order be made except upon a requisition requesting the same signed by a majority of the ratepayers supplied by such water race. (Amendment of 1898.)

GOVERNMENTAL PARTICIPATION IN DRAINAGE AND UNWATERING ONLY.

DENMARK.

Government participation in land reclamation in Denmark is confined to furnishing financial assistance to landowners who are desirous of draining morasses or heaths. For this purpose a yearly appropriation is usually made by the Rigsdag, to be expended under the direction of the department of agriculture. The sum appropriated depends upon the sums required for previously approved applications and amounted in 1906 to \$10,720. The manner in which the assistance of the department is secured is as follows:

When a landowner desires to obtain financial aid from the Government toward the reclamation of any heath lands, swamps, or morasses owned by him, he is required to make a formal petition to that effect to the governor of the province in which the land in question is situated, and must furnish in this petition a detailed account of his financial circumstances, stating also the area of the land he proposes to reclaim, how long the same has been in his possession, how many head of live stock he owns, the amount of insurance carried on the buildings, on the property, etc. Previously to sending in the petition he must apply to the Danish Heath Society to make a technical survey and examination of the property and report thereon as to whether the land in question can be successfully reclaimed. If the report is favorable, he submits it to the governor along with his petition. No petition will be considered that is not accompanied by a recommendation from the Heath Society.

No charge is made by the Heath Society for making the requisite technical examination and report; all the necessary plans for the reclamation of the land in question are also prepared by the engineers of the society without charge, and, if the petitioner's application is approved and the necessary appropriation made, the society supervises the work of reclamation. No charge is made by the Heath Society for such assistance except in cases where the work planned by the society is not carried out for the reason that the parties interested have not been able to come to an agreement as to the manner of its execution; in such a case the amount of the expenses in connection with the preliminary work is paid to the society.

The terms of the amortization of the government loans for land reclamation are as follows:

The rate of interest is fixed at 3 per cent per annum.

For the first five years the interest only is paid.

For the ensuing ten years $3\frac{1}{2}$ per cent of the original indebtedness is paid yearly.

For the ensuing period 5 per cent of the original indebtedness is paid yearly.

From the payments made from the sixth year onward, the interest upon the capital sum outstanding, reckoned at 3 per cent, is deducted, and the balance written off the principal. The debt is thus amortized in the forty-second year after contraction.

The manner in which a debt of, say, 10,000 kronen would be thus amortized is as follows:

Amortization of a debt of 10,000 kronen.

Years.	Principal.	Installment.	Applied as—	
			Interest.	Amortization.
I.....	10,000.00	300.00	300.00	Nil.
II.....	10,000.00	300.00	300.00	Nil.
III.....	10,000.00	300.00	300.00	Nil.
IV.....	10,000.00	300.00	300.00	Nil.
V.....	10,000.00	300.00	300.00	Nil.
VI.....	10,000.00	350.00	300.00	50.00
VII.....	9,950.00	350.00	298.50	51.50
VIII.....	9,898.50	350.00	296.97	53.03
IX.....	9,845.47	350.00	295.35	54.65
X.....	9,790.82	350.00	293.73	56.27
XI.....	9,734.55	350.00	292.05	57.95
XII.....	9,676.60	350.00	290.31	59.69
XIII.....	9,616.91	350.00	288.51	61.49
XIV.....	9,555.42	350.00	286.65	63.35
XV.....	9,492.07	350.00	284.76	65.24
XVI.....	9,426.83	500.00	282.81	217.19
XVII.....	9,209.64	500.00	276.30	223.70
XVIII.....	8,985.94	500.00	269.58	230.42

And so forth, until the debt is amortized, which, as stated above, will take place in the forty-second year after contraction.

GREECE.

The participation of the Greek Government in the reclamation of land has until lately been confined to granting upon certain conditions concessions for the draining and reclaiming of marshes and swamps to private individuals and associations who are willing to risk their capital in such enterprises.

These swamps and marshes are numerous, especially north of the Isthmus, and might in many cases, be restored to cultivation. The only important enterprise of the kind yet undertaken is the reclaiming of Lake Copais, an account of which undertaking is appended.

In the year 1889, the Bulé passed a bill empowering the minister of finance to contract a loan of about \$2,300,000 for drainage and irrigation in Thessaly; but the project never got beyond some preliminary surveys in that region. Another bill has been brought lately before the Bulé providing for the appropriation of 4,000,000 drachmai (about \$772,000) for the drainage of the marshes in Greece, but the sum asked for is regarded as being so inadequate that the results are not likely to prove valuable.

There is no general law defining the aid which the Government may extend to reclamation enterprises, a special agreement or convention being made between the Government and the company in each case approved; but the attitude of the Government in such matters may be estimated from the tenor of the law on "The Draining of Lakes," as follows:

I. Leave is hereby granted to the Government to concede to companies the right of the draining of lakes; and such concession shall also include the soil of the lake usually covered by water, lying within the circumference of the ordinary inundations. For every such concession a royal decree shall be promulgated on the motion of the council of ministers.

II. The following concessions may be made to companies undertaking the work of reclamation; (a) the absolute ownership of one-half of the reclaimed lands; (b) the usufruct for ninety-nine years of the remainder of the land con-

ceded; (c) exemption from all taxation for five years dating from the completion of the drainage operations; (d) the exemption from any duty on the lands conceded and on the buildings erected thereupon, and likewise on the material imported, necessary for draining, cultivation, or construction work, for a period of ten years from the issuance of the concession; (e) a proportionate tract of land, belonging to the State, round the lake, for the purpose of erecting warehouses or factories for the service of the company.

III. All construction work must be completed within ten years from the date of the concession; in default whereof the company shall pay into the public treasury a fine, the amount of which shall be fixed by the convention, but shall not be less than 5,000 drachmai (\$965); and shall moreover be declared deprived of its rights under the concession by decree of the council of ministers. In such case the works already executed remain the property of the defaulting company, but the Government shall concede the enterprise to another company on the conditions stated above.

IV. The ordinance of the law of 1867 and of the convention sanctioned by the same for the draining of the Lake Copais, so far as regards the determination of the two circumferences of the ordinary inundations, the trial of the claims that may be made by individuals for lands lying within the circumferences and the mode of indemnifying them shall apply also to the concessions that shall be made by virtue of the present law. The company has the right to claim from the owners of lands lying between the two circumferences one-third of the increase in value accruing to said lands from the reclamation work.

V. The amount of the guarantee to be paid into the public treasury by the company in conformity with the provisions of Clause III, the period fixed for the payment of the same, and the other details of the concession shall be fixed by the royal decree that shall be promulgated for the concession according to Clause I.

VI. The company undertaking the draining of any district shall be permitted to utilize the waters that inundated the same for the foundation of industrial establishments and for the general irrigation of lands, and to receive from the owners or occupiers of such lands a duty to be fixed by royal decree and not exceeding 3 drachmai per stremma (\$2.40 per acre).

THE RECLAMATION OF LAKE COPAIS.

Lake Copais was until recently a lake in Boeotia, surrounded by a stretch of swamp, the whole extending over about 60,000 acres. It forms the natural reservoir for a number of mountain streams, of which the most notable was anciently the Cephissus, and in modern times the Melas, or Black River. The depression is bordered on the east and northeast by limestone bluffs, pierced in many places by natural fissures (called Katavothra, lit. declivity), through which the surplus waters after reaching a certain level found their way by subterranean channels to the plains below, and in the case of the Grand Katavothra to an arm of the Euboean Sea, about 4 miles distant and 300 feet below the level of the lake.

Reclamation work in connection with this lake is known to have existed anciently, the ruins of an extensive canal and tunnel system (dating from the heroic age and probably the work of the Minyai of Orchomenos) having been discovered and explored. The subterranean canals were constructed much on the same principle as that employed in Persia at the present day for the conduits that bring the waters of the mountain springs to the cities, a series of shafts at short distances being sunk to facilitate the boring of the tunnel and removal of the excavated material. It is probable that as long as these tunnels were in working order the greater part of the lake was in cultivation.

Since the classical era no attempt was made to reclaim the marsh lands or submerged area until 1880, when a French company pro-

cured a concession for the draining and exploitation of the tract. The plan was to connect Copais with two other lakes at a lower level and from the lower of these to cut a channel to the sea. The company took six years to construct the works, and when the retaining dam was cut in June, 1886, the lake was emptied in forty-nine days. In the following year the original company went into liquidation and the project was taken up by an English company. The works completed in June, 1895, consisted of: (1) A grand canal with a total length of 19.87 miles, of which 6.6 miles lie in the marsh itself; the average width of the main channel is 78.7 feet; (2) an interior canal for surface draining; width, 65.6 feet; length, 14.54 miles; (3) a junction canal, 1.242 miles long, conducting the waters of the Cephissus River to the Melas; (4) canalization of the Melas River; width of channel, 72.2 feet to 85.2 feet; depth, 26.2 to 32.8 feet; length, 11.06 miles; (5) Karditza Outlet; length, 2.485 miles; width, 85.3 feet; depth, 52.5 feet; (6) Moriki Cutting, between Lakes Likeri and Paralimni; length, 0.93 mile; width, 82 feet; depth, 9.8 feet; (7) Karditza Tunnel; length, 689 yards; width, 52.5 feet; height, 39.3 feet; (8) Hangara Tunnel, between Lakes Hylicus and Paralimni; length, 1,071.74 yards; (9) Anthedon Tunnel, from Paralimni to the sea; length, 940.5 yards; width, 32.8 feet; height, 39.3 feet.

In the year 1894 there were in all 17,500 acres of reclaimed land in cultivation.

The contract between the Government and the company as to the reclaimed land is as follows: Three thousand seven hundred and fifty acres are to be distributed pro rata among those peasants who can make good their claims to property within the area conceded. At the end of ninety-nine years two-thirds of the total area reclaimed—say 40,000 acres—revert to the State and one-third—say 20,000 acres—remains the property of the company.

MEXICO.

The only public enterprise connected with the reclamation of land undertaken by the Federal Government has been the draining of the Valley of Mexico in the federal district of that name, but it has not been feasible to obtain particulars concerning these operations.

With respect to irrigation the Mexican Government has of late years shown recognition of the importance of the subject, and in 1894 a law was passed defining the terms upon which concessions with regard to operations for the utilization of water, either as a motive power or in irrigation, would be granted. The provisions of this act of 1894 are briefly as follows:

The plans of the proposed works, and full description of the aims of the enterprise, must be deposited with the Government within a stipulated period.

Construction work must be approved by a government inspector, whose fees are payable by the licensee.

A cash deposit, with a view of securing the fulfillment of the obligations contracted, is required of the licensee.

The prices and tariffs for sale or rental of water must receive the approval of the department of Fomento.

In consideration of the fulfillment of the above requirements, the licensee will receive (1) five years' exemption from taxation upon

the location and all constructions in connection with the works; (2) duty-free importation of all scientific instruments required in the location and construction of the works, and also of all machinery and other apparatus needed for the utilization of water in irrigation and as a motive power; (3) free occupation, for the purpose of constructing canals, dams, reservoirs, etc., of all national and vacant land required for the purpose; (4) the right to expropriate, for the purpose of the above construction, any private lands required for the same, compensating the owners according to the conditions established for the railroads.

On May 21, 1908, a bill was introduced by the department of finance and public credit, providing for the appropriation of \$25,000,000 in aid of land reclamation by means of irrigation.

According to a newspaper report of the matter, the main provisions of the bill are as follows:

The sum named, corresponding to nearly \$12,500,000, is to be included in the yearly budget of the department and applied as required in the form of subsidies to approved enterprises, such subsidies being payable on each hectare (2.47 acres) of land brought under irrigation, or on each cubic meter of water stored for the same purpose.

In connection with the scheme of subsidizing irrigation enterprises, it is proposed to establish a farmers' bank for the purpose of making loans on reasonable terms and for long periods to landowners who desire to improve their lands or to provide themselves with additional machinery. Free importation of agricultural implements, cattle for breeding purposes, seed and other products, is allowed under certain conditions, and freedom from export duties for all the products of the lands irrigated under the provisions of this act, for a term not longer than ten years, is also included in the provisions of the bill.

NORWAY.

Shallow lakes, sloughs, and peat bogs are found in all parts of the country, and many of these can be reclaimed and made productive by drainage and cultivation. The ownership is largely in private hands, but several of the marshes and bogs are on state property.

The Storting regularly sets aside an annual appropriation for the unwatering and drainage of waste lands and swamps, but the amounts thus appropriated are inadequate in view of the large areas of wholly unproductive lands which with comparatively small outlay could be converted into meadow lands, or at least into grazing pastures. It is conceded, however, that the drained peat bogs of Norway need continued cultivation and regular fertilizing for several years after unwatering, but this is a principle applicable to such lands in general.

The sum set aside by the Storting for drainage is \$5,000, the disposal of which is in the hands of the agricultural department. It is distributed in aid of persons possessing such lands as the inspectors of the department find worth draining. The inspector draws up plans and specifications for the proposed work, together with an estimate of the probable cost thereof, and the agricultural department will, upon his recommendation, contribute one-fourth of the estimated expense as a free gift. The Government controls the work until it

has been completed in accordance with the plans furnished and approved by the department.

State lands are drained upon the recommendation of the department of agriculture, provided the Storthing is willing to make the necessary appropriation. The reclaimed lands are disposed of as the Storthing decides; when sold, preference is given to the neighboring farmers or to the commune.

No statistics showing the total area reclaimed are available. The most valuable of the reclaimed lands in Norway are situated in the district called "Jaderen," near Stavanger. In this locality several large tracts of land have been unwatered and rendered productive by drainage; up to the present about 6,000 acres have been brought into cultivation. The soil in this tract is, generally speaking, more easily cultivated than elsewhere.

No irrigation system has as yet been inaugurated in any part of Norway. Some tracts in the valleys of the south are somewhat subject to drought, and irrigation might there be resorted to with advantage. Elevated lakes and water courses are as a rule found in their near vicinity, and an unfailing supply of irrigating water could therefore be provided at reasonable cost, but the farms are small and the Government has not as yet found it expedient to take the initiative in the matter.

SWEDEN.

Reclamation work in Sweden takes the form of drainage only and government aid is therefore restricted to fostering these operations.

All drainage work of a public character is carried out by the direction of construction of highways and waterworks and by the ministry of agriculture. Any person desiring to execute drainage operations upon his own land at his own expense may make application to the minister of agriculture to have the necessary plans drawn up and estimates of the cost of the work made, and this is done by government engineers, designated by the chief engineer of agriculture. The expense of the work is borne by the applicant, who may also pay for the services of a government engineer to construct and superintend the work.

Direct monetary aid toward reclamation by means of drainage is made in accordance with the law of 1901, whereby applications for assistance which have been examined into and approved by the direction of highways and waterworks and the ministry of agriculture (such examination and approval to include not merely the feasibility of the work, but also its economic value) and recommended in consequence, may receive, out of a special fund yearly set apart for that purpose, a grant in aid which may amount to as much as the whole cost of the contemplated improvement.

In such cases the construction and subsequent inspection of the reclamation work until such time as the loan has been repaid in full are in the hands of the government engineers, who report to the direction of highways and waterworks and the ministry of agriculture.

The loans made for this purpose are amortized in the following manner:

No payment of principal or interest is required during the first three years after the completion of the work.

During the next three years repayment of the principal is not required, but interest at the rate of 3.6 per cent is charged. From the seventh year onward a yearly rate of 6 per cent is payable, 3.6 being charged to interest and the balance written off the principal. The loan is thus amortized in the forty-ninth year after the contraction of the debt. Any landowner, however, may, if he choose, by giving six months' notice to the Government, pay off at any time the full amount of his indebtedness, with interest to date.

A special appropriation of 500,000 kronor (\$134,000) was made in 1907 in order to assist the landowners in Norrland in draining their properties. The state contribution in this case may not exceed 50 per cent of the total cost according to the estimate of the government engineers. The work must be carried out in strict accordance with the plans of the government engineers and must be approved by the direction of the highways and waterworks.

RECLAMATION BY PRIVATE ENTERPRISE.

BRAZIL.

As far as has been ascertained the Brazilian Government has not participated in any way in the reclamation of land either by drainage or irrigation. The policy of the Federal Government is to give all possible aid to deserving schemes for the national welfare and, when such enterprises are not undertaken independently by the state government, to further them either by direct intervention and control or by a guarantee of interest upon the capital outlay required for the enterprises. Up to the present this participation has been almost entirely confined to dock and harbor improvements, and the vast amount of virgin soil in Brazil yet unsettled renders it unlikely that the problem of land reclamation, whether by irrigation or drainage, will have more than an academic interest for the Brazilian legislators for some years to come.^a

CHILE.

Although the Chilean Government has hitherto taken no active part in land reclamation either by drainage or irrigation, the crop failures of the last three years have called public attention to the economic importance of water storage and distribution, and it is likely that before long the Government will bring forward some plan for utilizing the streams that descend the slopes of the Cordilleras for the public advantage, probably after a plan similar to that adopted in Argentina.

Several of the valleys along the Cordilleras range have been for many years under irrigation of a primitive character, and the comparison between the regular crops produced even by the crude meth-

^a In the summer of the present year the Brazilian Government has taken the initial step toward participation in land reclamation by sending to the United States for one year a state civil engineer with instructions to make a thorough study of the irrigation problems in the West. A large district in the north of Brazil suffers from drought and it is possible that when Engineer Baeta Neves's report is handed in some definite action with the view of reclaiming that area may be undertaken by the central Government.

ods employed by the native irrigators and the almost complete crop failures of the last three years on the unwatered plains below has been an object lesson for the Government and people that will assuredly bring results before long.

CHINA.

Although the question of irrigation is one of the greatest importance throughout the whole of the Chinese Empire, especially in the north, where year after year crop failures occur, immense districts are laid waste and much suffering ensues owing to the lack of measures being taken to conserve and utilize the rainfall, which runs to waste; yet hitherto the Government has, practically speaking, taken no official part in irrigation or land reclamation work in general. It is true that irrigation is extensively practised wherever feasible throughout the Empire, but this, as formerly in India, is entirely carried out by private enterprise and primitive methods. Community ditches, taken out of the navigable canals and operated by the villagers of the neighborhood, are to be seen wherever the canals themselves are carried and along the courses of many of the rivers.

Some provincial governments have of late shown interest in reclamation work. In the vicinity of the city of Hankow the plain above the city was turned every year into a vast lake by the overflow of the Han Ho,^a which empties into the Yangtse. The viceroy of the province ordered a dike to be built inclosing this plain, and through the regulation of the flood water the district has been turned into a region of great fertility, the outlay on the project being recouped by special taxation.

In northern China the irrigation question is of the highest economic importance. The rainfall is extremely variable, both as to quantity and season. In the best years there is a good rainfall during April and May and a heavier one between July and September, but periods of drought, extending over a whole year, followed by prolonged and disastrous floods, are frequently the rule rather than the exception. The drought areas are usually limited, but owing to the difficulties in the way of transportation, people within the drought district are often dying of famine while a few hundred miles away there is an abundant harvest. There is ample water to irrigate the whole of the territory, and no government enterprise which could be undertaken would confer a more direct benefit upon the inhabitants and realize at the same time better returns upon the capital invested. Two crops yearly can be raised upon all irrigated land south of the Great Wall. The physical conditions of the catchment areas render the installment of irrigation systems particularly simple and comparatively inexpensive, and water rates levied after the plan adopted by the provincial governments in India—a wet season and dry season rate—would insure an ample revenue to the province and at the same time immensely improve the condition of the individual farmer.

The following account of irrigation in the Shantung Province will be found of interest. On the Hsiafo Ho the community of Hsin-

^a Ho=river.

cheng have been operating an irrigation system for many generations, the water being stored in dams and distributed by canals. The district was in a highly prosperous condition and crop failures were unknown. A few years ago, however, the dwellers along the upper course of the river, who had for many years suffered from repeated droughts, adopted the same system as the Hsincheng people, with the result that the Hsincheng water, being impounded upstream, failed to reach the farmers below, and crop failure began in the lower district. After a lengthy dispute an arrangement has been arrived at whereby a more or less equitable division of the water is made between the two localities.

In the Tsechuan and Lintsehsien districts fine canals once bordered the Wu Ho. These, originally intended for carrying off the flood waters, proved of prime service for irrigation. Immense lateral distributaries were dug on both sides of the Wu, and the flood waters stored therein. After they had become stagnant and rich in decomposing vegetable matter they were discharged onto the fields and proved of great benefit to the agricultural population, without interfering with the normal flow of the river. During the last fifty years, however, the canal system has been allowed to fall into decay; the great laterals have been filled in and plowed over; in wet years the entire district is a stagnant marsh; in dry seasons there is a general crop failure.

The reconstruction of this important canal system is now to be taken in hand. The district has required every adjoining community to furnish a quota of laborers, and a scheme of paying for the work has been evolved. The governor of the province has been appealed to, and this official, recognizing the importance of the project, has promised to take up the matter of funds with the provincial treasurer.

ECUADOR.

The only official relation which the government of the Ecuadorean Republic has established with respect to land reclamation is in connection with the provisions of the "Ley de Aguas" or water law, to which all operations for the derivation and beneficial utilization of flowing water must conform. The main articles of the water law are as follows:

ARTICLE I. A cultivated tract of land lying below another must receive from the upper tract all such waters as naturally descend to it, and nothing may be done to interfere with a natural easement of water right either by the owner of the upper or lower tract.

II. A landowner may make use of water flowing naturally through his property, although he be not the owner of said water, for domestic purposes, for irrigation, to turn mills or other machinery, or to water his stock; but must provide an outlet by the natural channel for such water as he does not use in the manner above stated.

III. The use which a landowner may make of the water which traverses his land is further limited as follows: (1) The owner of the lower tract may acquire certain rights of user in the water coming from the upper tract through peaceful possession for a period of not less than ten years from the date of construction of visible and substantial works for the purpose of derivation of the water to the lower tract. (2) His use of the water must not contravene any of the laws and regulations applying to navigation or raft traffic, nor those which define the rights of riparian owners. (3) When the water is required for domestic purposes for a neighboring town. In this case, part of the water must be released to the landowner, who must further be indemnified for any loss sustained.

IV. The use of water running between two properties will belong to the two riparian owners in common, with the same limitations, and will be regulated in case of dispute by the competent authority.

V. The waters which pass through an artificial conduit belong exclusively to the constructor thereof, provided the legal requirements have been complied with.

VI. The owner of a tract of land may make what use he pleases of rain water running along a public highway, and may turn its course for his private use; no prescriptive rights can deprive him of this use.

VII. All landed property is subject to servitude for aqueducts in favor of owners of other lands which may not have the water necessary for their proper cultivation, whether the lands are to be seeded for crops, planted, or used as meadows; or in favor of a community requiring water for the domestic use of its inhabitants, or in favor of an industrial enterprise requiring the use of water for the operation of its machinery.

VIII. Houses, together with the yards, courts, orchards, and gardens appurtenant thereto, are exempt from this servitude of aqueducts.

IX. The water must be conveyed by conduits which do not leak, and which do not check the flow of the water or cause rubbish to accumulate, and which furnish at suitable intervals the bridges needed for the management and cultivation of the lands carrying the conduit.

X. The right of aqueduct includes that of selecting a route therefor which shall furnish an unobstructed incline for the water and, considering the physical conditions, will not make the work unnecessarily expensive. When these conditions are satisfied, the conduit shall take the route which shall cause least damage to the cultivated lands. Proof to the contrary being wanting, the shortest route will be considered the best for all parties concerned. The judge will as far as possible protect the interests of both parties; in doubtful cases he will decide in favor of the landowners.

XI. The owner of the servient property has the right to be paid the value of all the land occupied by the aqueduct and of a strip not less than 1 meter (39.37 inches), or more by mutual agreement, on either side of the conduit along its entire course, and 10 per cent of the sum total in addition. He also has a right to be indemnified for any damage caused by the construction of the aqueduct, or from filtration or leakage due to defective construction.

XII. The owner of the servient property is obliged to admit workmen thereto for the purpose of cleaning or repairing the aqueduct, previous notice having been given to the person in charge of the property. Similarly, and with similar notice, he must admit an inspector or care taker.

XIII. Any landowner already possessing an aqueduct of his own upon his property may object to the construction of another thereon, offering passage through his own aqueduct to the water which the other desires to use; provided that such an arrangement is not distinctly prejudicial to the party desiring to construct the new aqueduct. If this offer is accepted, payment must be made to the owner of the servient property of the value of the land occupied by the old aqueduct and the lateral strips as in Article XI, according to the proportional volume of the new water introduced into the aqueduct, and of a similar proportion of the cost of the work for the distance for which it is required by the other party, who shall if necessary enlarge the aqueduct at his own expense.

XIV. If any one owner of an aqueduct on alien property desires to carry by it a greater volume of water, he may do so, making good any damage to the servient property, and if new construction is needed the provisions of Article XI will apply thereto.

XV. The regulations concerning servitude of aqueducts apply also to constructions for the outlet and control of excess waters, and the draining of pools and swamps by ditches and drainage canals.

XVI. If an aqueduct is abandoned, the title to the property and the exclusive use reverts to the owner of the servient property, who is not obliged to return any part of the price paid him for the value of the land.

XVII. If a stream of water belonging to private parties impedes or hinders communication between neighboring tracts, or interferes with irrigation or drainage ditches, the party interested in the water must construct the bridges, canals, or other works required in order to abate this nuisance.

XVIII. Persons desiring to carry water to their property may construct not more than one conduit in the servient tract; and if this is destroyed, or if the owner of the dominant tract abandons it, the water may be conducted by another channel, with consideration of the least possible damage to the servient property.

XIX. In the exercise of the rights referred to in the preceding articles, any property owner, persons dwelling in or near a settlement, or parties desiring to install and operate machinery, may take water from the rivers, lakes, or public sources.

XX. If the party constructing an intake or canal, with the intention of carrying water, abandons the work for a period longer than one year, it will be understood that he has renounced his right and title in the same, and any other person is permitted to open a fresh intake or canal.

PERSIA.

Although the pressing need for the installation of some national system of irrigation, operated or subsidized by the Government, as well as the certain financial success of such an enterprise, if rightly managed, is fully conceded by all competent authorities in Persia, the lately established constitutional government has not yet found it possible to give any consideration to the question of official participation in land reclamation of any kind, and all that is done in that direction in this country at the present day in the way of irrigation is either the result of individual effort or of the operations of small syndicates or associations of irrigators. The land throughout the northern portion of the territory is extremely rich, and the same may be said of the soil in all the valleys; and even the plains below, at present barren wastes, could be restored to their former fertile and cultivated condition by the reforestation of the denuded areas of the foothills and the conservation of the rainfall. There are ample evidences that in ancient times the country was brought into a state of intense cultivation by means of irrigation, and supported thereby a population fully as dense as that of the State of New Jersey at the present day. The ruins of canals and aqueducts of solid brick and masonry construction attest the value which the former inhabitants placed upon the storage and distribution of water. The present production of wheat and other cereals is far below the needs of the population, and the national interests in general would be greatly advanced if the Government were to undertake the development of the irrigation of suitable tracts somewhat after the plan pursued so successfully in the Punjab.

The means whereby the chief cities, such as Teheran and Tabriz, are supplied with water is interesting. Both of these cities are situated not far—Tabriz about 40 miles, Teheran about 30—from a range of mountains, and the valleys among the foothills abound with springs. The water from these springs is conducted to the city by underground conduits tunneled through the clay subsoil at depths varying from 20 to more than 100 feet. These tunnels are about 5 feet in diameter and are cut out of the clay without supports of any kind, a shaft of the same diameter as the tunnel being dug about every 70 or 80 feet and serving to carry off the excavated earth. The preceding shaft is then carefully covered over and the tunnel carried forward for another section. In the city these shafts are provided with wooden caps and serve as manholes. Although there are in Teheran about 500 such conduits (and in Tabriz nearly as many) passing above and below one another on their way to the houses they supply, and constructed, apparently, haphazard, yet one tunnel rarely, if ever, infringes upon another. In Teheran (and probably

in Tabriz also) the tunneling is done by a class of men trained to the work from childhood and perfectly familiar with the intricate underground windings of the conduits. Each of these springs and conduits usually belongs to some citizen of standing, who, after the needs of his house and garden are supplied, furnishes water to his neighbors at a fixed rate. These rates may not be altered except by special decree, nor may the water owner refuse to furnish his neighbors with water when called upon to do so. In case of refusal, he is liable to be summoned to court and heavily fined. Plans for supplying these cities with water from artesian wells and piping the supply to each householder have been considered, but the ancient water custom is against the probability of financial success. The water from some of the mountain springs is conveyed to the city in open channels and furnishes irrigation to the neighboring farms and orchards. In these cases, also, the owner of the water must comply with the requirements of his water users if he has an available supply. The water rates are very high, and the business of furnishing water is an extremely profitable one.

PERU.

The Government of Peru does not extend any aid to irrigation and drainage enterprises. All the irrigation works are built and operated by private companies. Congress has enacted certain laws having reference to charges for and supply of water, but nothing further.

SALVADOR.

The only irrigation works in this country with which the authorities have any connection are those executed on a very limited scale in the Department of Sonsonato, which were constructed by the Spaniards long before the advent of the republican régime and for the service of which the municipality of Sonsonato charges a small yearly fee for the benefit of the public hospital.

No drainage works exist in any section of this country; no laws regarding irrigation exist; no government aid or subsidy has ever been dispensed to such improvements; there is no geological survey or director thereof, and no printed data are available regarding the subject in general.

SERVIA.

The Government in Servia does not extend any special aid to land reclamation or irrigation. A primitive method of furnishing water is in use among the peasantry, who are assisted to a small extent by a society called the "Agricultural Cooperative Society." The system employed is the wheel-and-bucket—locally called the "dolap"—and the method of operation is similar to that employed in India, horses being used instead of oxen. These dolaps are constructed by the cooperative society, who lease them to the farmers for a small yearly payment. The society receives a subsidy from the Government in the form of a share of the profits of the state lottery.

TURKEY.

No official information or data of any sort have been obtainable with respect to the attitude of the Government of the Sublime Porte toward irrigation or the subject of land reclamation in general, but it may be stated that the Ottoman Government has rarely if ever directly contributed to the development of any such projects. While it is true that the greater part of the country now forming the Asiatic dominion of the Ottoman Empire has been almost from the earliest recorded period the scene of irrigation operations of every sort and extent, from the one-man shaduf to the great canal systems of the Tigris and Euphrates valleys, and that the greater portion of the cultivated area of Asiatic Turkey owes its productivity almost entirely to the artificial application of moisture to the soil, yet whatever development has taken place in this direction during modern times has been due to the energy of individuals or village communities, aided now and then in a spasmodic and capricious manner by the governors of the vilayets or provinces, who have sometimes found it to their interest to support or even take part in the enterprise of the inhabitants. In this regard, however, the Statesman's Year Book states that in 1907 the Ottoman Government entered into a contract with the Anatolia Railway Company, whereby the latter agrees to furnish the funds (some \$4,000,000) for the construction of irrigation works in the neighborhood of Konia in Asia Minor. The construction work is to begin this year, and must be finished within five years. The project when completed will be controlled and managed by the civil list department. Concerning this project, which is not only the most important undertaking of the sort projected in Asia in modern times, but one which, if fully carried out, is expected to supply water to more than 2,000,000 acres, the following, adopted from an account published by a Smyrna newspaper, will be found of interest:

The largest of the fresh-water lakes in the vilayet of Konia in Asiatic Turkey is the Bey Chehir. It is fed by numerous mountain streams, and has an area of nearly 25,000 acres. The difference between the lowest level in November and the highest level in May is more than 16 feet. The overflow from the lake passes through the river of the same name, 37 miles in length, to Lake Karaviran. Along the southern shore of this lake numerous fissures provide a subterranean outlet for the ordinary overflow of the lake. The eastern normal outlet of the lake is by the River Tcherchembe, which flows for some distance through the great salt-impregnated plain that forms so large a portion of the whole province, and finally disappears in the sands of the waste.

The general scheme which the project is to carry out includes the storage of the waters of Lake Bey Chehir, the canalization of the river issuing therefrom, and the consequent cultivation of the bed of Lake Karaviran, which, under present conditions, is either in flood time a fetid swamp or in dry seasons a worthless waste; and in addition a vast area now valueless, extending for many miles beyond Karaviran on both sides of the Baghdad Railway, will be brought into cultivation and rendered productive. Briefly stated, the engineering project is as follows:

The Bey Chehir will be turned into an irrigation reservoir by means of a dam at its lower extremity, 200 feet in length and 13 feet above mean supply level. Sluice gates and regulators will lead the water to the Bey Chehir River, which will be regulated along its whole length of 35 miles, and will run between masonry dikes a little above the present embouchure to Lake Karaviran. Sluice gates from this embankment will provide escape for flood waters in time of necessity and a passage into the subterranean stream.

From the Karaviran dike a canal 18 miles in length will be constructed to the Tcherchembe River. This canal will have a width of 80 feet throughout its length, and will skirt the shore of the present Lake Karaviran, which will first be drained and then irrigated from the dike sluices above the lake. The canal is then turned into the channel of the Tcherchembe, whose course it follows for nearly 30 miles, when it is carried south by means of an aqueduct across the river bed to the district of Choumbra. The total length of the canal will be 125 miles, and of the distributaries 1,250 miles. The gaugings for the last three years give the overflow from Bey Chehir Lake as varying between 14,000,000,000 and 21,000,000,000 cubic feet (from about 300,000 acre-feet to 450,000 acre-feet). When the contents of the Lake Bey Chehir are added to the available supply—which they will eventually be, as soon as the irrigation of the land on both sides of the Tcherchembe Canal and of Lake Karaviran is accomplished—it is estimated that the storage capacity and flood waters of the reservoir will be sufficient for the irrigation of more than 2,000,000 acres. According to the contractors' estimates, the cost of the undertaking, providing only for the irrigation of the railway land and Lake Karaviran, will amount to about \$30 an acre. A scheme of assisted immigration has been drawn up, whereby the first settlers will receive contributions toward stocking and cultivating their farms, and it is expected that in this way the whole district will be rapidly settled. The profit accruing to the Anatolian Railway, in the shape of increased traffic, will be considerable from the first, and it was with this end in view that the project was originally promoted.



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